

# A TEXTBOOK OF SURGERY

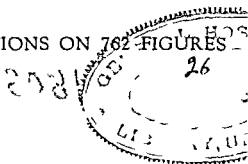
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## PREFACE TO THE FOURTH EDITION

The greatly increased utilization of the third edition of this textbook not only in military but also in civilian practice has imposed upon the editor and the contributors a distinct obligation to bring the fourth edition completely up to date and make it a cross sectional presentation of the best in American Surgery.

Of special value in this edition are two entirely new sections one on Military Surgery by Colonel Edward D. Churchill Consultant in Surgery in the North African Theater and Professor of Surgery at Harvard Medical School and the other on Chemotherapy in Surgical Infections by Dr. John S. Lockwood Associate Professor of Surgery, Yale Medical School. The latter explains fully the uses of penicillin and the sulfonamides. Other entirely new sections include the following: Actinomycosis by Dr. Owen H. Wangenstein Professor of Surgery, University of Minnesota Medical School; Burns by Dr. Oliver Cope Assistant Professor of Surgery, Harvard Medical School; Shock by Dr. Alfred Blalock Professor of Surgery, Johns Hopkins Medical School; Indolent Ulcers by Dr. Louis G. Herrmann Associate Professor of Surgery, University of Cincinnati Medical School; Vascular Tissue Tumors by Dr. Arthur Purdy Stout Professor of Surgical Pathology, Columbus University; Tumors of the Sympathetic Nervous System by Dr. William DeW. Andrus Associate Professor of Surgery, Cornell University Medical School; Fractures of the Radius and Ulna by Dr. Harrison L. McLaughlin Associate Professor of Surgery, Columbia University; Tumors of the Breast by Dr. Alexander Brunswick Professor of Surgery, University of Chicago; Inflammations of the Chest Wall by Dr. William E. Adams Associate Professor of Surgery, University of Chicago; Wounds of the Thorax by Dr. William F.

Rienhoff Jr. Associate Professor of Surgery, Johns Hopkins Medical School; Pilonidal Sinuses and Cysts by Colonel Idys Mims Gage Associate Professor of Surgery, Tulane University; The Peritoneum by Dr. Harold D. Harvey Associate Professor of Surgery, Columbia University; Diverticulitis and Ulcerative Colitis by Dr. Richard B. Cattell of the Lahey Clinic; Unusual Hernias by Dr. J. Dewey Bigsard Associate Professor of Surgery, University of Nebraska Medical School; Diverticula of the Urinary Bladder by Dr. Charles Huggins Associate Professor of Surgery, University of Chicago; Diseases of the Vulva by Dr. H. Close Hesselting Associate Professor of Gynecology, University of Chicago; and Vaginal Fistula by Dr. Virgil S. Counsellor of the Mayo Clinic.

Two contributors have been lost by death: Dr. Mont R. Reid whose section on Wounds has been revised by Dr. Jonathan E. Rhoads Professor of Surgery, University of Pennsylvania; and Dr. Sanford R. Gifford. The sections on dislocations written by the late Willis C. Campbell have been revised by Dr. J. Spencer Speed Professor of Orthopedic Surgery, University of Tennessee; and Dr. Everts A. Graham's section on the Islands of Langerhans has been revised by Dr. Nathan A. Womack Professor of Surgery, Washington University Medical School. Especially extensive revisions have been made by Dr. Geza de Tikats of the sections on Varicose Veins and Venous Thrombosis and by Dr. James C. White of the section on the Autonomic Nervous System.

The editor wishes to thank the contributors for their enthusiasm and loyal cooperation in helping to make this an up to date practical treatise on surgery.

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## PREFACE TO THE FIRST EDITION

The dominant plan of this textbook is to give the student a concise presentation of surgery which is characterized by the maximum authority. The many advances in different branches of surgery which have been made in recent years have rendered it impossible for any one person to be experienced in and intimately acquainted with all of them. The plan of collaboration has been employed successfully in internal medicine and in the various surgical specialties.

The contributors whose painstaking work has made this book possible have been chosen after careful thought and consultation because of their outstanding ability in the subjects which they present. With few exceptions these men are actively engaged in teaching surgery to medical students. Each contributor has presented his material in the manner he has found to be most successful in instructing his students.

The subject matter contains the tested and accepted present day principles of surgery. Debatable or incompletely tried methods are not included. Where the author may show a personal preference to a particular line of treatment he has been careful to present other well known and acceptable methods. Etiology, pathology, and diagnosis have properly been stressed and the correct surgical treatment has been carefully described.

The editor can only inadequately express his gratitude to the many who have helped him in the preparation of this book. First of all is an appreciation of the fine spirit of loyalty and cooperation shown by the contributors. It is their book. Secondly, go thanks to many individuals who have helped. The wise and friendly counsel of Dr. E. Starr Judd was of first importance

to the undertaking. By his lamentable death the nation lost an outstanding surgeon whose vast amount of work was characterized by calm, clear judgment and brilliant manual dexterity. Dr. Loyal Davis has given valuable aid in the selection of the contributors to the section on Neurological Surgery. The advice of Dr. Sumner L. Koch in formulating the underlying principles of presentation and teaching values is much appreciated. Drs. Clay Ray, Murray, Jerome P. Webster, and Roscoe C. Webb have given enthusiastic and understanding assistance. Drs. Dean D. Lewis, Frederic W. Bancroft, Vernon C. David, George J. Heuer, and others have given valuable advice. Dr. William C. Danforth has helped in the selection of the contributors to the gynecological section and has edited their manuscripts. Since receiving their excellent manuscripts, the editor has learned with great regret of the deaths of Drs. John F. Connors and W. V. Mullin.

My associates Dr. W. Kenneth Jennings and Dr. H. R. Reichman have helped greatly in the editorial work. Miss Dorothy Watt, of the editorial department of the American Medical Association, has assisted in the preparation of the manuscripts and in the proofreading. Mr. Tom Jones has given invaluable help in the selection, arrangement, and improvement of the illustrations. Miss Mary Dixon of the Art Department of Northwestern University Medical School has retouched and redrawn many of the figures.

The editor is greatly indebted to W. B. Saunders Company for encouragement and many constructive suggestions.

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# I. INFLAMMATION AND REPAIR OF TISSUE

## INFLAMMATION

Inflammation is the most fundamental of all pathologic processes from the point of view of the surgeon. It is the local reaction of the body to irritation and not only is the surgeon concerned with removing irritants and aiding the tissues to resist their action but he produces some degree of inflammation with every stroke of the knife. Moreover inflammation blends so imperceptibly with the process of repair that it is impossible to say in any given case where one ceases and the other begins.

**Causes**—To enumerate the causes of inflammation would merely be to give a list of every known irritant. The chief surgical irritants are pathogenic microorganisms, physical and chemical agents and trauma. Animal parasites are of little importance in this respect. Physical irritants include foreign bodies, radiation (x rays and radium), electricity, heat and cold. Among the most important surgical chemical irritants are antiseptics. Trauma if severe enough will produce inflammation for reasons which will presently be explained.

**The Nature of Inflammation**—The object of the inflammatory process is to neutralize and remove an irritant. In the higher animals and in man this attempt is associated with striking changes in the blood vessels. These changes, although responsible for such clinical manifestations of inflammation as heat, redness, swelling and pain, are not the essence of the process. Metchnikoff long ago demonstrated that inflammation is the local reaction of the tissues to irritation, is present in animals which have no vascular system as well as in those supplied with blood vessels. The essential element in inflammation in all animals from the highest to the lowest is the reaction of the wandering mesodermal cells against an irritant. In the higher animals these cells are for the most part within blood vessels in the form of leukocytes, although the wandering cells of the tissues also play an important part. As the leukocytes are inside the vessels

while the irritant is outside it is obvious that by some device they must be transferred from the inside to the outside. Moreover the body fluids also play a part in the neutralization of bacterial toxins in the formation of fibrin and in other ways, and as these fluids are for the most part inside the vessels they also must escape to the outside. The series of steps by which the contents of the blood vessels are transferred from the inside to the outside constitute the vascular phenomenon, and they are responsible for the clinical signs of inflammation.

The above description speaks of object and purpose. Such a teleological explanation is convenient and appeals to the practical surgeon, but strictly speaking it is not justifiable. The events of the inflammatory process are impersonal physicochemical phenomena which have developed in the course of evolution because those animals able to react to injurious irritants in this manner survived while those unable to do so perished.

**The Vascular Phenomena**—In order to bring about the results just outlined two factors are necessary: (1) an increased supply of blood must be brought to the part; (2) the permeability of the vessels must be greatly increased. The all important increase in vessel permeability must be due to some locally produced agent. Sir Thomas Lewis has shown that the flushing of the skin which follows firm stroking is due to the action of a histamine-like substance (II substance). Histamine increases vessel permeability in addition to producing dilatation. As Lewis puts it: "The agent which alarms the garrison and mobilizes the first or vascular defences is a chemical agent derived from the tissues." Metchnik in an extended series of studies has succeeded in isolating from experimentally produced inflammatory exudates factors which appear to play an important part in the process. One of these factors he calls *leukotaxine* because it increases capillary permeability to a marked degree and thereby permits outward passage of leukocytes. It seems to be an intermediary breakdown product of pro-

tein metabolism. When this substance is injected locally, the increased capillary permeability is followed by rapid migration of polymorphonuclear leukocytes. It is definitely chemotactic. Another factor in the exudate is capable of causing a marked increase in the number of circulating leukocytes in the normal animal.

The result of the alarm and mobilization of the garrison referred to by Lewis is the series of vascular changes first described by Cohnheim in 1877 which form a striking phenomenon when viewed in the living animal but which can also be studied at lei-

is certain to result in necrosis of some of the tissue involved.

With slowing of the blood stream there is a rearrangement of the blood cells: the leukocytes fall out of the central current and are dragged along the walls to which here and there they adhere until finally the vessel wall is lined by these cells, a condition known as pavementing. This is brought about by an increased stickiness of the leukocytes due to an alteration in surface tension, this change being in turn caused by bacterial or other toxins which have penetrated the wall of the vessel. The wall itself

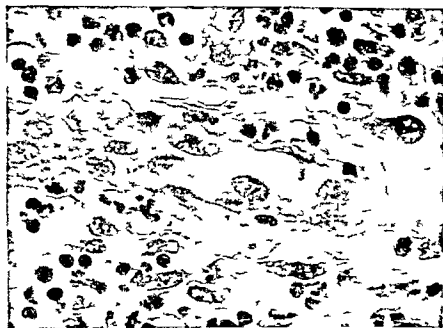


Fig. 1—Acute inflammation: slowing vascular dilatation, swelling of endothelium, loosening of the texture of the wall and outwandering of leukocytes to form the inflammatory exudate.  $\times 60$

sure in fixed tissues. The small vessels after a brief preliminary contraction undergo marked dilatation so that the part becomes flooded with blood and an enormous number of capillaries come into view which previously were invisible. This is the cause of the reddening which is so characteristic a feature of inflamed tissue and also of the increased heat of the part. Although temporarily quickened the blood flow soon becomes slowed and the leukocytes the total number of which may by this time be increased accumulate within the vessels. Should the irritation be severe there may be complete stoppage or stasis of the blood flow followed by thrombosis, an event which

is meanwhile undergoing a change. The endothelial cells become greatly swollen and project into the lumen thus assisting in no small measure the tendency to slowing of the flow. In addition the wall of the vessel appears to become looser in texture so that the outlines of its constituent parts are lost and it becomes more or less of a protoplasmic sponge. It will readily be appreciated how these changes which are seen particularly in the venules and capillaries affect the permeability of the vessel wall so that the contents can pass from the lumen into the surrounding tissue and thus gain access to the irritant.

It is not necessary to describe in detail

the well known process of the emigration of the leukocytes (Fig 1) the motive power of which appears to be an alteration of surface tension on the side next to the vessel wall produced by some diffusible chemical agent such as Menkin's leukotaxine. The first of the blood cells to pass through are the polymorphonuclear leukocytes and these may be followed later by monocytes, lymphocytes and erythrocytes. The plasma also escapes through the permeable vessel wall. In the vicinity of the vessel these various elements together with additions from the tissues form the inflammatory exudate.

**Inflammatory Exudate.**—The inflammatory exudate which forms at the seat of irritation is partly cellular and partly fluid in character. The cells are derived from the blood and from the tissues; the fluid comes from the blood. It is evident that the composition of the exudate will vary enormously depending largely on the nature and intensity of the irritant. Consider for a moment the following irritants: *Staphylococcus aureus*, anthrax bacillus, *Treponema pallidum*, the sting of a bee, a surgical knife and a sprain. For each of these the type of exudate produced will be markedly different from that found in the others. In this brief review of the inflammatory process a detailed analysis of these variations is impossible but they must be kept in mind in interpreting what follows.

The polymorphonuclear leukocyte is the principal cell in the acute inflammatory reaction to a pyogenic bacterium and it constitutes the chief element of ordinary pus so that it is commonly spoken of as a pus cell. It is derived entirely from the blood. In acute inflammation the number of these cells in the blood is greatly increased and as they are formed in the bone marrow it is evident that some chemical agent (such as Menkin's leukotaxine producing factor present even in non bacterial inflammatory exudates) must be carried from the seat of the inflammation to the marrow by the blood stream. The appearance they present depends largely on their freshness. They are seen to best advantage in an acute gonorrheal discharge where they escape at once from the body. When retained within the tissues for some time they suffer at the hands of the bacterial toxins and either lose

their sharpness or are completely disintegrated. They are actively phagocytic for bacteria and form the first line of cellular defense. On disintegrating they liberate proteolytic ferments which liquefy the dead tissue and thus play an essential part in the production of pus.

The eosinophilic leukocyte plays no part of importance in an acute inflammatory process but in subacute and chronic inflammatory conditions it is sometimes present in large numbers. In subsiding appendicitis it may form one of the chief constituents of the exudate. Many of the cells may be derived from the tissues as well as from the blood.

The lymphocyte is the chief element of the familiar 'small round cell infiltration' which is the characteristic reaction to a mild or chronic irritant and is present in enormous numbers in tuberculosis and syphilis. In spite of this fact its function in inflammation is at present unknown. Most of these cells are derived from the tissues but it is possible that some may come from the blood.

The plasma cell is probably derived from the lymphocyte and it appears under similar conditions. It is particularly characteristic of syphilitic lesions and often forms the principal cell in chronic inflammation of joints.

The histiocyte or macrophage (the former name indicating its origin, the latter its appearance and function) is one of the most important elements of the inflammatory exudate on account of its great phagocytic power. It is seen in the later stages of inflammation where it plays the part of a scavenger cell for dead material but it also forms the principal cellular defense against many bacterial and protozoal infections. Most if not all of these cells are histogenous in origin being derived from the wandering elements of the reticuloendothelial system, the histiocytes of the tissues. They give rise to the epithelioid cells of tuberculosis and other chronic inflammations and when they fuse together they form the familiar foreign body giant cells.

Red blood cells form a prominent part of the exudate in hemorrhagic inflammations of which anthrax is an excellent example. Here there is actual destruction of the cap-



illary wall but it is probable that red cells can pass through a wall which is damaged but still intact

The *lymph of the exudate* is derived from the blood and represents an outflow so great that the lymphatics are unable to cope with it so that it accumulates in the tissues. The amount of lymph depends partly on the nature of the irritant and partly on the type of tissue (open or dense) in which the exudate occurs. In some forms of inflammation it forms the bulk of the exudate e.g. in the sting of an insect.

*Fibrin* is formed from the lymph of the exudate being the resultant of the action of the thrombin liberated by disintegration of the blood platelets on the fibrinogen of the plasma. The amount formed will again depend on the nature of the irritant and on the site of the exudate. Pneumococcal and diphtheritic exudates are usually rich in fibrin and it is on serous membranes that it is formed most abundantly. Fibrin forms the scaffold on which the superstructure of repair is erected. It is also responsible for the formation of adhesions which tend to limit the spread of the inflammatory process.

**The Localization of Infection**—The inflammatory reaction tends to prevent the dissemination of infection. Speaking generally, the more intense the reaction the more likely is the infection to remain localized. Much depends on the nature of the infecting agent. *Staphylococci* produce an acute inflammatory lesion in which the bacteria tend to remain confined to the lesion owing perhaps at least in part to the coagulase which they produce. *Streptococci* tend to spread through the tissues and along lymph channels aided in this by the fibrinolysin which they form.

Menkin has called attention in experimental inflammation to the importance of mechanical obstruction in limiting the spread of infection. This obstruction is due partly to the formation of a network of fibrin and partly to occlusion of the lymphatic channels. The mechanical factors tend to cause what may be called *fixation* of the infective agent in the early stages before phagocytes have time to accumulate.

**Changes in the Tissues**—An irritant affects not only the blood vessels and their contents but the tissues with which it comes

in contact. The tissue change depends on the nature and intensity of the irritant. Any irritant if weakened sufficiently becomes a stimulant and the farther a tissue is from the site of the irritant the stronger will be the tendency to stimulation rather than destruction. The effect of stimulation is hyperplasia but as this is concerned with the subject of repair it will not be considered further here. Only the changes produced in the neighborhood of an acute irritant such as one of the pyogenic cocci will be discussed.

The bacterial toxins first cause cellular degeneration (cloudy swelling fatty degeneration) and then death (necrosis) of the tissue all the more readily if vascular stasis and thrombosis have occurred. The fate of the dead tissue depends to a large extent on the number of leucocytes present. When these are numerous they liberate during disintegration a proteolytic ferment sufficient in amount to cause liquefaction of the dead tissue. Thus at the site of the acute irritant liquefied necrotic material inflammatory lymph in which fibrin formation is inhibited by the action of the ferments and polymorphonuclear leucocytes are found. The resulting mixture is known as pus and the process of production is called suppuration. If the process is localized in abscess is formed if it is diffuse and spreading the result is cellulitis.

*Pus* is a yellowish material with an alkaline reaction containing leucocytes which may or may not be well preserved occasional lymphocytes mononuclears and necrotic tissue cells and living or dead bacteria. It does not coagulate because of the enzymes of the leucocytes thus the pus of empyema will not clot when removed from the body although the serous exudate of pleurisy will form a thick jelly under similar circumstances. Its physical characters depend on the infecting organism. *Staphylococcal* pus is creamy in consistency and has a mawkish odor streptococcal pus is sero-fibrinous and without odor. *Bacillus coli* pus has a characteristic fecal odor. *B. pyocyaneus* pus is greenish or blue tuberculous pus is flaky.

**Chronic Inflammation**—This is the reaction of the tissues to a low grade of irritation which may be bacterial or non bacte-

rial. The principal cells are lymphocytes, plasma cells and macrophages, all of which are probably histogenous in origin. Polymorphonuclears are few or absent. Fibroblastic proliferation followed later by fibrosis is always a marked feature. In its purest form it is seen around a foreign body. Two examples of special surgical interest are leopodium granuloma and traumatic fat necrosis. *Lycopodium granuloma* is the result of a granulomatous reaction around the dead spores of the club moss *Lycopodium clavatum* which constitute the leopodium powder used for dusting surgical gloves. The lesion consists of an area of necrosis, lymphocytes, epithelioid cells, multinucleated giant cells and fibroblasts. The large spores which are stained a bright red in Ziehl-Neelsen preparations serve to distinguish the lesions from tubercles. The small nodules which may be scattered over the peritoneum as the result of a previous operation may be mistaken by the surgeon for tubercles. Similar lesions are caused by the talc crystals of talcum powder. *Traumatic fat necrosis* is the result of injury to the fat cells of the subcutaneous tissue of the breast. A chronic inflammatory reaction develops around the necrotic tissue characterized by the presence of foreign body giant cells and later by fibrosis. The resulting nodule may also be mistaken for an infective lesion.

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#### THE REPAIR OF TISSUE

Since the science of surgery is primarily dependent on the ability of tissue to repair itself, knowledge of the processes of repair

and the extent to which restoration of normal structure may be expected is essential to the surgeon. While highly specialized tissue such as the kidneys, brain and glandular organs repair injuries to themselves by the formation of fibrous tissue, other less specialized tissue may rebuild itself in a form almost identical with the normal structure. John McCrae has expressed this difference in a striking comparison:

The parenchymatous cell is the professional man in a community specially trained not to be replaced by one of his own class. Impressionable by even slight external stimuli, not prone to be physically hardy, not overgiven to reproduction. The supporting cell on the other hand is its laboring-class brother, not trained in any high special task, whose supportive work can be replaced by any kind of tissue, even scar tissue, not readily impressionable even by powerful external stimuli, physically strong and ready in reproduction. These two cells side by side in the kidney, exposed to the same toxic influences, but reacting to them each in its own way. A toxin strong enough seriously to damage the high-class cell is only strong enough to irritate the low-class cell to reproduction. When the high-class cell is killed by toxins, there is absence of regeneration by the remaining tubular cells, and it leaves no one of its kind in its stead. Its place is occupied, but its function is not performed by the progeny of its laboring-class brother.

#### PHYSIOLOGY OF REPAIR

The repair of tissue is stimulated by the injury to the tissue cells, whether the injury is an intentional division, as in an operation, or accidental. The damaged cells liberate a tissue extract which calls forth a fibroplastic response from the surrounding tissue. The work done by Menkin<sup>1</sup> further confirms this theory. He has for the sake of convenience named the active substance 'leukotoxine'. It is capable of rapidly initiating the usual sequences of inflammation by inducing a prompt increase in capillary permeability and by causing an extremely rapid aggregation and migration of leukocytes through the endothelial wall. The fibrin trabeculae in the exudate and blood clot form the framework for subsequent tissue growth. In small incised wounds repair begins earlier than in large surface wounds, so that factors other than the liberation of tissue juices are involved. In clean wounds with a minimum of trauma repair begins soon after the injury and proceeds rapidly to complete healing, whether with replacement of the original tis-

sue or with substitution of fibrous or scar tissue. The presence of suppuration retards the healing process. The age and the nutrition of the patient also influence the rate of healing as does the nutrition to the area of the wound. In well vascularized areas such as the face wounds heal with much greater rapidity than in a region with a small blood supply. When the blood supply of an area is affected by one of a number of vascular lesions resulting in a diminished blood flow the wounds may show little or no tendency to heal. In the past it was generally accepted that profound anemia retarded wound healing but according to Besser and Ehrenhaft<sup>7</sup> anemia in itself does not inhibit wound healing. Severely anemic patients often have protein and vitamin deficiencies which probably account for the poor wound healing observed. It follows that any mechanical restriction of the arterial blood supply will also interfere with healing. Too tight bandages, pressure from splints or pads, excessive suture tension and tension from hemorrhage within the tissues are some of the more common mechanical causes of non healing.

The biological factors which influence wound healing have received considerable attention during the past few years. The excellent review by Arey<sup>3</sup> on wound healing indicates how many factors may influence the process. Lanman and Ingalls<sup>4</sup> have shown that vitamin C deficiency may cause a marked retardation in healing.

Surveys by Holman<sup>5</sup>, Rinehart<sup>6</sup> and others have shown that many persons do not have an optimum vitamin C level. In the group of medical students studied by Holman 26.6 per cent had a vitamin C plasma level which was within the range in which the symptoms of scurvy have been observed. A very low level of plasma vitamin C is the rule in many surgical patients, especially those with chronic infections, carcinoma and peptic ulcer.

Hardin<sup>7</sup> among others has reported that vitamins A and D in the form of cod liver oil stimulate wound healing. Brush and Lam<sup>8</sup> in a controlled experiment were unable to demonstrate any beneficial effect upon wound healing which they could attribute to the local application of vitamins A and D. If there is evidence or reasonable

suspicion of deficiencies of vitamins A and D it would seem in the light of present knowledge that to obtain any possible effect upon wound healing the most direct attack would be to administer these vitamins systemically rather than locally.

Protein is necessary for adequate wound healing. A protein deficiency retards fibroblastic proliferation whereas adequate protein stores and a high protein diet accelerate fibroplasia. Thompson, Ravdin and Frank<sup>9</sup> found that 72 per cent of the wounds of hypoproteinemc animals either failed to heal or disrupted. In a study of wound disruption in patients Hartzell, Winfield and Irvin<sup>10</sup> found either a protein deficiency or a vitamin C deficiency or both. Evidence is gradually accumulating which shows that a serious protein deficit is more often present than a vitamin C deficiency. Without adequate building material satisfactory repair cannot take place.

Fluid and electrolyte balance are also important factors in wound healing. According to Herrmannsdorfer<sup>11</sup> alkalosis inhibits and acidosis apparently favors wound healing. It is of the utmost importance that the surgeon keep his patient in proper fluid and electrolyte balance.

The widespread use of sulfonamide compounds has raised the question as to whether or not these substances interfere with wound healing. Systemically administered sulfanilamide and sulfadiazine do not interfere with normal wound healing of the abdominal wall and the stomach according to Zintel and his associates.<sup>12</sup> Taffel and Harvey<sup>13</sup> also found no inhibition of wound healing of the stomach when sulfanilamide was so administered. Bricker and Graham<sup>14</sup> on the other hand reported that systemically administered sulfanilamide did impair wound healing.

In regard to the local use of sulfonamides it must be recognized that large amounts do interfere with wound healing. This is obvious because dead spaces are created which lead to serum collections and because crabs or concretions are formed when the less soluble sulfonamides are employed. When used in amounts of 0.1 Gm. per square inch of wound surface Zintel<sup>15</sup> found that sulfanilamide did not interfere with normal wound healing whereas sulfathiazole in equal amounts did impair the tensile strength of

healing soft tissue wounds in animals Key and Burford<sup>10</sup> found that sulfanilamide did not interfere with healing of experimental fractures

Splinting of a wound in most cases favors healing since it prevents destruction of new tissue by motion or tension Careful suturing of an operative wound holds the tissues in apposition during repair Complete rest is essential in nerve and tendon repair and this is obtained in part by adequate suture and in part by immobilization Occasionally repair progresses to a certain point and then ceases but may be reinitiated by irritation This is sometimes true in callus formation

tion of the scab During the lag phase the serum and blood form a coagulum which is simply a fibrin network which contains leukocytes and red blood cells As the two surfaces of an incision thus become glued together some of the coagulum may exude from the surface of the wound to form a crust or scab Some lymph exudes into the wound but this is usually of small amount in a cleanly incised wound The phase of fibroplasia begins from three to five days after injury The fibroblasts begin to divide by mitosis and grow along and into the fibrin network formed during the lag phase The fibrin network is gradually absorbed by



Fig 2—Photomicrograph of a section of a healing wound in a rabbit's tongue Observe the fibrin in the upper part of the picture the fibroblasts at A and the capillary loop growing at B  $\times 80$

after fracture when there is delayed or non union further callus may form if there is some friction between the ununited ends

**Healing by First Intention**—The ideal toward which every surgeon strives is to obtain primary healing of a wound without delay and without infection As a result of the incision there is injury to the adjacent tissue cells with escape of tissue fluid which is believed to be the initiating factor in repair

The actual process of wound healing is familiar to every student of pathology The process is divided into three phases the first phase is the lag phase second the phase of fibroplasia and third the phase of contrac-

tion of the scar During the lag phase the serum and blood form a coagulum which is simply a fibrin network which contains leukocytes and red blood cells As the two surfaces of an incision thus become glued together some of the coagulum may exude from the surface of the wound to form a crust or scab Some lymph exudes into the wound but this is usually of small amount in a cleanly incised wound The phase of fibroplasia begins from three to five days after injury The fibroblasts begin to divide by mitosis and grow along and into the fibrin network formed during the lag phase The fibrin network is gradually absorbed by

tion the fibrous tissue which results from the healing gradually contracts. Small new capillaries are squeezed until they are obliterated. This contraction continues for an indefinite period, often for as long as a year.

During the lag phase and the early part of the phase of fibroplasia, the strength of

tures has come from the work of Howes and Harvey.<sup>17</sup>

The surgeon must plan each incision so that the contraction of the scar will least distort and thereby least interfere with the function of the surrounding tissues. In a large wound in which the edges are not



Fig 3—A later stage in the repair of a wound in a rabbit's tongue. The fibrin is replaced by dense scar tissue, and most of the capillaries have been obliterated by its contracture. The epithelium has grown over the surface;  $\times 460$ .

the wound is very slight. The rapid ascent of the tensile strength curve from the sixth to the tenth day has great practical significance as regards the type of sutures used, and the stress thrown on the wound must be considered with this in view. Valuable information on the tensile strength of healing wounds and the tensile strength of su-

closely approximated, the closure of the defect is due more to the contraction of the fibroblasts than to the actual filling effect of the proliferating tissue.

Scar tissue is never as resistant to tension as normal tissue, and if present in any amount, it may prove to be a vulnerable point in any area subjected to pressure or

tion. It is desirable therefore to have the least possible amount of scar tissue following an abdominal incision. Occasionally even though the wound surfaces have been accurately approximated fibroplasia may continue until the cicatrix becomes the site of a new growth. Instead of cessation of fibrous tissue formation as soon as continuity is re-established proliferation of fibroblasts continues with the resulting formation of a *keloid*.

**Healing by Second Intention**—There are a number of factors which may inhibit or retard healing some of which have already been discussed. If the loss of tissue

tissue. Obviously there is more scar tissue present in these wounds the amount depending on the amount of tissue destroyed and the area to be restored. Epithelization occurs on the surface as a rule only when the depths of the wound are filled with granulation tissue.

An aseptic hematoma also may delay healing by the mechanical separation of tissue and when healing finally occurs a greater amount of fibrous tissue will be present. Devitalized tissue from mass ligatures or from crushing by hemostats also will delay healing even in the absence of organisms, but too often this tissue forms



Fig. 4.—Epithelium growing over granulation tissue. Note the exaggerated downward growths commonly seen where healing has been difficult.

has been so extensive as to prevent accurate approximation or if infection develops primary union does not occur. Instead there is healing by second intention. When a tissue defect is present the reactions of repair are similar to those observed in healing by primary intention but are greater and more prolonged in duration. In an infected wound the extent and virulence of the infection determine the degree of retardation of wound repair. In the presence of infection there is an outpouring of exudate and a migration of polymorphonuclear leukocytes into the wound. This together with the tissue debris makes up the pus which is found in such a wound. When the infection has been overcome the filling of the wound will proceed again by the formation of granula-

tion. A favorable site for infection. Foreign bodies acting as tissue irritants likewise retard or inhibit healing.

**Healing by Third Intention (Secondary Suture)**—Occasionally a wound is left open for some purpose the granulating surfaces being sutured together a few days later or after infection with delayed healing the granulating surfaces are approximated to hasten healing and to lessen the formation of fibrous tissue. This then is known as secondary suture or healing by third intention.

While this discussion has mainly concerned itself with repair of incised wounds there are many other types with which the surgeon must deal. In a large denuded area the very size of the defect may defeat the

process of repair Epithelization from the peripheral epithelium will continue only for a certain distance and then a chronic ulcer may remain If the area to be covered is large new skin must be added usually by the use of skin grafts placed on the healthy granulation tissue If considerable scar tissue formation occurs at the periphery and base of a large surface wound the contraction of this tissue may so restrict the blood supply that further repair in the central portion of the wound ceases It may then become necessary to remove the fibrous tissue or to supply additional tissue by means of flaps or pedicle grafts

### REPAIR OF SPECIAL TISSUES

**Epithelium**—Epithelium has marked powers of regeneration as a rule In the skin and mucous membrane there is rapid repair and often complete restoration of the typical cellular arrangement

**Muscle**—As in certain other tissues cells of the muscle do not take part in the process of repair Outgrowths from the fibrous tissue of the muscle sheath and the partitions between groups of muscle fibers form the new fibrous tissue which unites the separated muscle All necrotic or severely damaged muscle in a wound should be removed because it will not be regenerated and its presence will only retard healing and increase the amount of the cicatrix Obviously the smaller the amount of scar tissue necessary to fill the defect the less interference will there be with function

**Tendons**—Tendons are made up mainly of parallel closely adjacent collagenous bundles Fibroblasts are the only cells present They have a very limited blood supply the small vessels being carried in the mesotendon a fold passing from the sheath to the tendon much like the intestinal mesentery The mesotendon may be absent in certain locations or it may be a rudimentary structure When tendons are divided the mesotendon may stretch and form a bridge between the retracted ends

After division or rupture of a tendon exudate and blood fill the space between the ends A moderately rapid growth of granulation tissue replaces the exudate and soon fibroplastic proliferation into the granulation tissue occurs The growth about the

ends of the tendon frequently resembles in shape the callus formation in a fracture Shortly the new tissue becomes avascular and takes on the characteristic tenuous form The increase in the length of the tendon under such circumstances frequently leads to loss of function

When the tendon sheath also is divided the structures must be carefully sutured or in all probability normal healing will not take place, instead scar tissue will form which penetrates to the surrounding tissue and results in loss of function To avoid this the tendon should be carefully sutured or if the retraction has been too great or a part of the tendon lost so that the ends cannot be approximated the gap should be bridged by tendon grafts or tendon plastic procedures In this manner firm union will occur by the usual method of tendon repair

In a discussion of tendon repair the excellent article by Mason and Shearman<sup>18</sup> is of interest

The tendon itself takes an important part in healing but because of its scanty blood supply and the very nature of its tissue it begins its proliferation later and it progresses more slowly than ordinary connective tissue This tardiness of tendon response is compensated to some extent by the early response of the sheath

To take advantage of tendon proliferation one must carefully avoid traumatizing the tendon and especially must one avoid injury to the ends of the tendon that one wishes to bring together These studies have shown that the tendon ends start to proliferate about the fourth or fifth day after suture and to send out bands of cells and fibrils into the gap tissue beyond If the tendon is injured or if it is stripped of blood supply necrosis is likely to occur and delay the process It is shown by histologic study of healing tendon sutures that union is effected first by proliferation of the sheath tissues This union serves to reestablish continuity in a few days After the fourth or fifth day the tendon itself begins to proliferate and to send cells into the callus and if the gap is not too great it may be bridged by tendon cells in about two weeks After the sheath has served its purpose of splinting the first union it begins to become more lax and areolar and in a successful suture to take on again its original function of serving as gliding tissue

**Bone**—While the structure of the bone involved modifies the form of repair the same principles of healing are followed as in other tissue After a fracture which usually is associated with more or less laceration of the periosteum and trauma to the surrounding soft parts a clot forms between the ends of the fractured bone After this

there occurs an exudate from the vessel and swelling of the surrounding tissue. The typical proliferation of connective tissue from the endosteum, the periosteum and the haversian canals and the formation of epiphyseal buds follow rapidly.

Thus far repair has been much the same as in any tissue. The cells of the periosteum and the endosteum however have osteogenic properties and from these osteoblasts new bone tissue forms. The clot is absorbed and replaced by vascular and new osteoid tissue. The osteoblasts have fibrils which ex-

rapidly of healing. Immobilization is essential though if the injury is near or into a joint it is necessary by early motion to prevent permanent restriction of joint motion.

**Gastrointestinal Tract**—After division of the stomach or of the intestine the portion to be closed or the parts to be anastomosed must be sutured in such a way that serosa will unite with serosa and mucosa with mucosa. The importance of careful approximation of serosal surfaces cannot be overemphasized because it is only by careful serosal suture and the subsequent

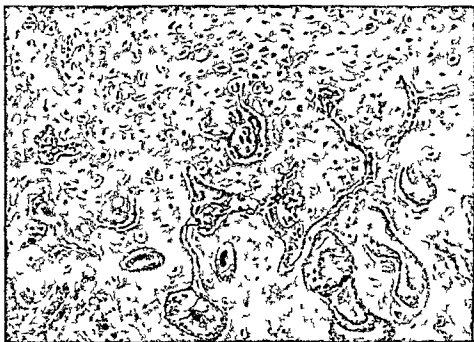


Fig 5—Invasion of callus by osteoblasts

tend in all direction and these fibrils as well as the cells themselves become embedded in a homogeneous matrix. When calcium salts are deposited within the osteoid tissue it becomes a spongy, osseous tissue—the *callus*. This calcium then undergoes partial absorption as new and firmer bone is laid down within it. The superfluous external callus is all absorbed until the normal contour of the bone is restored. In long bones with a vascular marrow healing occurs more rapidly than in flat bones. Bones with little or no periosteum such as the carpal bones and the patella heal slowly.

Just as in soft tissue careful approximation of the ends of the fractured bone is important not only for the final structural and functional result but to increase the

rapid sealing of the wound with exudate that leakage of intestinal contents into the peritoneal cavity can be prevented. As soon as the serosal surfaces are sutured the exudate forms and effectively seals the union. As in other epithelial wounds this exudate is invaded by granulation tissue from the subserous connective tissue. Healing is more rapid than in other epithelial tissue. The united mucosa which has been inverted into the lumen by the suture undergoes more or less necrosis along the suture line but as this sloughs off granulation tissue forms and is then replaced by new mucous membrane which may in every way resemble the normal tissue.

The site of a carefully made intestinal anastomosis may show very little scar tis-



sue and little or no contraction. Since the blood supply of the intestine is through vessels from the mesentery which run circularly not longitudinally in the wall of the intestine it is obvious that healing will not occur and necrosis will develop in an area that is stripped of its mesentery beyond the limits of the anastomosing vessels.

**Nervous Tissue**—Nerve cells which have been destroyed are not replaced. However the various parts of a cell may regenerate if the cell itself remains alive. When a peripheral nerve is divided the axon will grow in a peripheral direction and function will be restored. As in other highly specialized tissue the connective tissue which grows more rapidly than the specialized tissues may surround it and check further growth.

I S RAYDIN

Revised by H A ZINTFL

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## II. BACTERIOLOGY OF SURGERY

### RELATIONSHIP OF BACTERIOLOGY TO SURGERY

#### WHY SHOULD A SURGEON BE INTERESTED IN BACTERIOLOGY?

**The Contamination of Operative Wounds**—Every operative wound made by a surgeon is contaminated with bacteria. Before the time of Pasteur and Lister the vast majority of surgical wounds became infected. This effectively limited the scope of surgery to emergency measures on superficial easily approachable lesions. The inner parts of the body were unapproachable because of the fatal outcome of any infection within them. Thanks to these great geniuses ways and means have been found by which we prevent the occurrence of wound infections. All of the thousand and one steps in the sterile technic which have been elaborated are directed toward minimizing the contamination of the operative wound. The surgeon must know the sources from which these organisms come and must develop his sterile sense to such a point that he will not be responsible for any contamination which might be avoided.

**Surgical Infections**—From one third to one half of a surgeon's practice concerns lesions which have been contaminated with or infected by bacteria before the patient comes to him. Any one who visits a general hospital and makes the rounds from bed to bed in any general surgical ward will find every second or third bed occupied by the victim of an infection which was established before he entered the hospital or by the victim of an injury with a potentially infected wound. Any one who visits the surgical outpatient department finds an even larger proportion of infections among the patients who are treated there. The surgeon must therefore know how to treat lesions which have been produced by bacteria or which have been contaminated by them.

**Postoperative Infections**—Bacteria are frequently responsible for serious postoperative complications. As a result of the anesthetic or of the operative procedure itself

there are certain disturbances of the normal physiology of the respiratory, alimentary and urinary tracts. At such times bacteria may invade the physiologic interior of the body or in his efforts to restore the normal physiology the surgeon or his aides may introduce bacteria into regions which are normally free from them. The surgeon must know how to avoid these physiologic disturbances and how to prevent the contamination of clean tissues during or after operation.

#### WHY IS STERILE TECHNIC NECESSARY?

**Before and After Lister**—In this present day and age any one who attempts to perform surgical operations conforms more or less rigidly to certain rules of procedure known as sterile technic. Just so far as these rules are followed infections of operative wounds are reduced just so far as these rules are ignored infections of operative wounds are increased. Only those whose practice extends back over sixty years have any conception of the state of affairs before the various steps in sterile technic were adopted. However vivid word pictures have been left for us to read and frequent reference should be made to them lest we forget what would surely be the outcome if we abandoned the practices which we now employ.

Nowadays a study of wound infections in clean cases gives no adequate picture of what occurred before 1875 but it reveals the fact that there are still sources of wound contamination which have not been eradicated. Doors do not have to be opened very widely for bacteria to enter from a number of different directions and the modern surgeon must be on guard constantly to keep every means of entrance closed.

**Present Day Sources of Contamination of Clean Wounds**—If one were to ask the average surgeon how often his clean wounds become infected he would probably answer: Very seldom, not once in a hundred times or I haven't had an infection in

years" Unless that statement is backed up by actual records the chances are that that would be an understatement of the facts. In most hospitals careful records of wound healing are not kept. In some hospitals however such records are kept and analyzed at frequent intervals in order to keep the staff keenly alert to prevent wound contamination and to improve the record of wound healing. In one such hospital where the question has been studied carefully for eighteen years where the records have been scrupulously kept for every clean case in which an operation has been performed and where the condition of the wounds at subsequent dressings has been consistently scrutinized the following facts have been brought out:

a General impressions regarding wound infections are not accurate. The actual number will vary from 5 to 20 per cent or more of all clean cases. Of these from 1 to 5 per cent will be serious resulting in pain, fever, suppuration, weakness of the wound, disruption or hernia, prolonged hospitalization and occasionally death. The others may be called trivial but they are annoying to the patient and usually delay his departure from the hospital. In the average case of infection the patient must remain in the hospital just twice as long as the patient in whom infection does not occur.

b The organisms which have been cultured from wound infections in clean cases give a clue to their origin.

Over a period of eight years in the Presbyterian Hospital, New York, while there was complete masking of the nose and throat of all persons entering the operating room, a record was kept of the various organisms found in the inflammatory exudate of clean wound infections. The percentage of incidence of these organisms is shown in table 1. It is seen that the staphylococci composed by far the most common group occurring in two thirds of all the infections. The hemolytic *Staphylococcus aureus* was found in almost one third of all the serious infections and the *Staphylococcus albus* was the chief offender in the trivial infections being present in almost two fifths of the cases. The hemolytic and non hemolytic streptococci were found in 4 and 5 per cent, respectively. The hemolytic variety was more serious than the non hemolytic and both of them were found more often in serious than in trivial infections. *Bact. coli* and *Bacillus proteus* were somewhat more likely to produce serious than trivial infections and *B. pyocyaneus* while not occurring so frequently were invariably serious. On the other hand *B. subtilis* and the diphtheroid bacilli

which are ordinarily not considered pathogenic occasionally caused trivial infections and when found were frequently in pure culture. Among the others the only organism of importance was *C. urechei* which occurred once in an amputation stump and was probably present in the gangrenous foot requiring the amputation.

Where did these organisms come from? We know that staphylococci are frequently found on the skin and probably frequently lodge live and perhaps grow in the sebaceous and the sweat ducts and in the hair follicles. They are also commonly found in the air. When blood agar plates have been exposed in an operating room while an operation was in progress as many as one to two colonies of bacteria per minute of exposure have appeared after the plates have been incubated. This would mean that from 30,000 to 60,000 bacteria are deposited from the air on the sterile field during the average operation. Staphylococci represent a large proportion of these organisms. If plates are exposed in an operating room when no operation is in progress and no one enters, the number of colonies is reduced to 10 per cent of the above figure. They are almost invariably present also in the human nasal passages and are discharged during expiration. These organisms occasionally also contaminate the operating room tables, the pads or the floor when the pus from infected cases caused by them is allowed to escape at the time of operation. Likewise the floor of the operating room may be contaminated with staphylococci from material which is brought in on street shoes and which when dried may be carried about on currents of air.

Streptococci are not commonly found on the skin but are occasionally found on blood agar plates exposed to the air. The hemolytic variety is frequently found in the throat and more rarely in the nose. The non hemolytic streptococci are invariably present in the throat and are frequent in the nose. Both staphylococci and streptococci are often picked up by the hands and clothing of doctors and nurses when landing or dressing patients. Both streptococci and staphylococci are easily killed by relatively low degrees of heat and could hardly escape death in the autoclave or instrument sterilizer even when too brief or inadequate temperatures fail to kill many other organisms. For that reason supplies and instruments and catgut may be practically eliminated as possible sources of these organisms unless they have been contaminated from other sources after sterilization.

*Bacillus subtilis* and the diphtheroid bacilli are of little importance although *B. subtilis* which produces a resistant spore is an excellent test organism for the adequacy of sterilization. Both of these groups of bacteria are frequently found on the skin and on blood agar plates exposed to the air.

*Bacterium coli*, *Bacillus proteus* and *B. pyocyaneus* are most commonly found in the intestinal tract and are therefore frequently picked up by the hands of doctors and nurses. They are occasionally found on plates exposed to the air but not as frequently as the other organisms.

**How Can We Minimize the Contamination of the Operative Wound by These**

TABLE 1—INCIDENCE OF THE VARIOUS ORGANISMS FOUND IN CLEAN WOUND INFECTIONS FOR EIGHT YEARS OF COMPLETE MASKING AT OPERATION

Organisms	Serious per cent	Trivial per cent	Total per cent
Hemolytic streptococcus	9	2	4
Non hemolytic streptococcus	7	4	5
Hemolytic <i>Staphylococcus aureus</i>	30	16	22
Non hemolytic <i>Staphylococcus aureus</i>	13	14	14
<i>Staphylococcus albus</i>	19	38	31
<i>Bacterium coli</i>	7	6	6
<i>Bacillus proteus</i>	3	2	3
<i>Bacillus pyocyaneus</i>	4	0	1
<i>Bacillus subtilis</i>	4	7	6
Diphtheroids	0	6	4
Others	2	4	4

**Organisms?**—It would seem that the chief sources of contamination are, in the order of their importance (1) the skin of the patient, (2) the noses and throats of persons in the operating room (3) the hands of the operating personnel (4) the air of the operating room and (5) the instruments and materials

1 Contamination from the skin of the patient may be minimized but with our present knowledge it can not be entirely prevented. No antiseptic yet devised is able to destroy all of the bacteria deep down in the hair follicles and sebaceous glands. During the operation some of these are undoubtedly cast out in the secretion of the skin glands. When the scalpel cuts through the skin it carries some of these organisms into the wound. If the cautery knife is used to make the incision and if the edges of the skin are then fastened with Michel clips to towels these sources of contamination will be reduced. Sterilization of the skin seems to be the weakest link in the chain of sterile technique and careful search should be continued for a more penetrating and more effective antiseptic. In our laboratory Krauss and Cimotti have experimented on the skin of rabbits with all the advocated skin antiseptics including iodine (alcohol and water soluble), mercurochrome, metaphen, merthiolate, acriflavine, gentian violet, methyl violet and brilliant green, hexyl resorcinol, sodium hypochlorite and azochloramide. When bits of skin are snipped out after contact with these preparations, water soluble iodine solutions consistently give the highest percentage of sterile cultures but even iodine does not give more than 60 to 70 per cent sterility leaving much to be desired.

2 Contamination of the wound by organisms from the nose and throat may be minimized by completely covering the nose and mouth with an impermeable

mask or a four ply fine meshed gauze mask which will catch the droplets which are invariably expelled during coughing, talking or breathing. A helmet should cover the head and neck. This will serve to divert air currents during expiration down into the gown. These currents might otherwise carry bacteria around the mask and on to the sterile field.

3 Contamination from the surgeon's hands may be minimized by prolonged scrubbing with soap and hot water to remove the top layers of keratinized skin and the accompanying bacteria and then by washing in an antiseptic solution. It has been demonstrated that a mixture of chloride of lime and sodium carbonate is effective for this purpose. However this is irritating to the skin of some persons and less active substances may have to be employed for example, bichloride or bimide of mercury (1:1000) [70 per cent alcohol—Ed].

4 Contamination from the air may be minimized by limiting the number of persons entering the operating room before as well as during the operation by minimizing the opening and closing of doors and the activity within the room during the operation by covering as much of the sterile field as possible with canopies by covering the hair, the nose and mouth and the feet of all those who enter the operating room by filtering the air either before it enters the room or by circulating it through a filter in the room by having as few as possible dust-collecting objects in the operating room and by frequently cleaning the walls, ceiling and floor. Studies by Wells<sup>14</sup> and also by Hart<sup>15</sup> have demonstrated the possibility of minimizing air contamination by the use of ultraviolet radiation in the operating room. Suitable apparatus is now available which releases a high percentage of rays from the bactericidal zone of the ultraviolet spectrum the intensity of which can be accurately measured. Krauss, Cimotti and Meleney<sup>17</sup> have shown that effective intensities can be obtained which are not injurious to the tissues

but which will reduce air contamination to one tenth or one twentieth of the amount normally found in the operating room

5 Contamination from autoclaved supplies should be absolutely prevented. If an adequate vacuum is used before the steam is introduced there should be no difficulty in destroying all bacteria (fifteen minutes' vacuum and forty-five minutes' sterilization at from 18 to 20 pounds of pressure is a safe standard). If less time is given for the preliminary period of evacuation, a longer time will be required for sterilization. The turning device invented by Walter<sup>64</sup> for keeping the autoclave locked until sterilization is complete is an added safeguard which is of considerable value. The boiling of instruments is perhaps the most efficient method of killing the bacteria on them and if sufficient time is given—from five to ten minutes—one need have no fear of contamination from these sources. A few pathogenic strains of spore-forming organisms have been reported on which will resist boiling for fifteen to twenty minutes or longer but for all practical purposes the time just mentioned will be adequate. Sharp instruments such as knife blades, scissors and needles are generally and properly sterilized by prolonged soaking in a non-corrosive antiseptic such as the Bard Parker solution. Instruments and sponges constantly transfer into the wound organisms which have dropped on them from the air or which have been transferred from other contaminated objects. They thus act as secondary rather than primary sources of contamination.

### ESTABLISHED SURGICAL INFECTIONS

**Definitions.**—Infectious diseases are those disorders of the animal body resulting from the entrance of micro-organisms into the tissues where they can live, grow, multiply and carry on their metabolic processes. Surgical infections are those which, according to the best medical opinion, should be treated by operative means. The factors which make an infectious disease amenable to surgical therapy depend on whether the lesion is likely to resolve spontaneously or is likely to produce necrosis of tissue or a localized collection of purulent exudate which can be excised, incised or drained with relatively little harm to the body as a whole. *If, with a minimum of injury, the whole or a large part of the focus of infection can be removed, a surgical procedure is warranted, but the good that is accomplished must outweigh the harm that is done.* For example, an acutely inflamed appendix, a chronically infected gallbladder or a pyonephrosis may be excised; an abscess of a lymphatic gland may be drained, and cellulitis of the neck which will probably produce edema of the glottis may be incised. On the other hand, surgical procedures are not warranted if the

infection is one which ordinarily subsides spontaneously, such as pneumonitis or phlebitis; if it is one which responds to medication, as, for example, a syphilitic lesion, or if it is one which yields to rest and sunshine, like certain tuberculous processes; or if there has been little destruction of tissue, as in a low grade cellulitis, or if the process is generalized, as in miliary tuberculosis. Similarly, if the lesion is inaccessible because of intervening parts, as in bronchial lymphadenitis, or because its exact location is not known, as in many cases of septicemia, or because it involves some essential organ, such as the valves of the heart, surgical procedures in their present stage of development are contraindicated because they would do more harm than good. Organisms which produce lesions in the body which warrant surgical treatment are those which either cause local death of tissue or cause the exudation of leukocytes in large number, in other words, necrotizing or pyogenic organisms.

**What Organisms Produce Surgical Infections?**—Most of the micro-organisms which have been found to exist in nature are of little concern to those who are solely interested in human infectious diseases. A great host of organisms, however, are of vital interest because they make life possible by completing the cycle of physical and chemical processes which cause the disintegration of dead animals and plants into the simple chemicals which plants require for their own synthesis. The plants are in turn consumed by and make possible the growth of animals and man. Of the relatively small group of bacteria which are pathogenic for man, a still smaller number produce surgical diseases. These will be considered in the following order:

#### I Aerobic bacteria

##### A Aerobic cocci

##### (I) Gram positive

##### (A) *Streptococci*

1 hemolytic

2 non-hemolytic

##### (B) *Staphylococci*

1 aureus

2 albus

##### (C) *Pneumococci*

##### (II) Gram negative

##### (A) *Gonococci*

## B Aerobic bacilli

## (I) Gram positive

(A) *Bacillus tuberculosis*(B) *B. anthracis*(C) *B. licheniae*(D) *Diphtheria bacilli*(F) *B. subtilis*

## (II) Gram negative

(A) *Bact. coli*(B) *Bact. typhosum*(C) *Bacillus nuceus capsulatus*(D) *B. paratyphosus*(E) *B. proteus*(F) *Hemophilus influenzae*(G) *B. malle*

## II Anaerobic bacteria

## A Anaerobic cocci

## (I) Gram positive

(1) *Streptococci*

## B Anaerobic bacilli

## (I) Gram positive clostridia

(A) *C. welchii*(B) *C. novus*(C) *C. septicum*(D) *C. sordellii*(F) *C. tetani*

## (II) Gram negative

## III Micro-aerophilic organisms

## A Streptococci

## (I) hemolytic

## (II) non hemolytic

## IV Spirochetes

## A Higher micro-organisms

A Actinomyces

B Blastomyces

C Coccidio des

D Sporotricha

In the following paragraphs a brief account is given of the surgical infections caused by these various organisms. For the morphologic and cultural characteristics of these bacteria the reader is referred to text books of bacteriology.

## I AEROBIC BACTERIA

## A AEROBIC COCCI

(I) Gram Positive Cocci (A) Streptococci—The only significant division of this group is based on the lytic action of the organism on red blood cells. Streptococci which produce hemolysis are in general of considerable virulence and those which do not are relatively avirulent.

1 *Hemolytic Streptococci*—Previous to 1930 hemolytic streptococci were the cause of most of the fulminating cases of blood poisoning. The discovery and rapidly spreading use of sulfanilamide however have not only saved many patients with

septicemia who otherwise would have died but the control of local infections due to this organism in the early stages has in recent years often prevented the development of septicemia. This has rendered infections with hemolytic streptococci less menacing than formerly and the non hemolytic streptococci which sulfanilamide does not control have become relatively more important. They are frequently found in the throats of normal persons especially during the late winter and early spring months and are widely disseminated from that source so that many persons acquire the organisms when in crowded places and pass them on to others through the medium of handkerchiefs, hands or droplets discharged from the nose or mouth with breathing or coughing. Streptococci probably do not live for a long time outside the animal body but when they are fairly directly transferred from one human environment to another small numbers are able to produce disease.

Hemolytic streptococci enter the body most often through an accidental wound such infections being much more frequent in the later winter and early spring than at other times of the year. Just how the organisms live, grow and spread in such a wound will be discussed later. Suffice it to say here that they usually produce cellulitis in such wounds and frequently cause lymphangitis, lymphadenitis, suppurative phlebitis and septicemia or they may very rapidly produce extensive gangrene of the skin.<sup>2</sup> When streptococci persist in the blood stream because of the presence of an overwhelming distributing focus of infection they may settle in the spleen, liver, kidney or bone marrow, gain a foothold and produce other metastatic abscesses. In children they frequently localize in joints particularly the hip joint or in the neighboring epiphyses.

Hemolytic streptococci may invade the body through the throat and tonsils and spread to the cervical lymph glands where they produce adenitis which is frequently accompanied by high fever and profound intoxication. Such an infection may persist for weeks for the glands are slow to resolve or slow to liquefy and form an abscess. The organisms may produce diffuse cellulitis of the neck which may spread to the glottis and by a rapidly developing edema threaten

suffocation Hemolytic streptococci are frequently found in cases of acute peritonitis. Usually in such instances there is a history of previous upper respiratory infection. It is possible to cultivate the organisms from the blood in many of these cases. Hemolytic streptococci may also enter the body through the lungs producing pneumonia and suppurative pleurisy. Hemolytic streptococci are by far the most common organisms in

pathogenic strains from human sources in a single group by the employment of a precipitin test. Apparently the differences depend not so much on the particular type of hemolytic streptococcus as on the portal of its entry into the body and the resistance or susceptibility of the local tissues of the host.

2 *Non Hemolytic Streptococci*—In the production of surgical infections there is

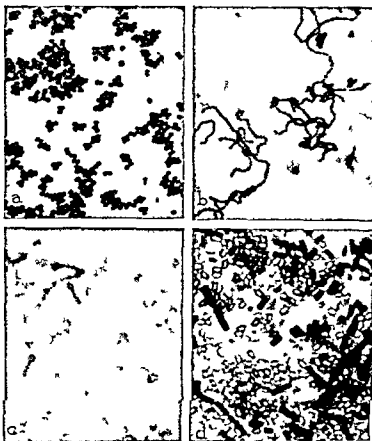


Fig 6—*a* Staphylococci from broth culture  $\times 1500$  *b* hemolytic streptococci from blood broth culture  $\times 1400$  *c* round-end spore-forming gram-positive bacillus *C. tetani* from old cooked meat culture medium  $\times 1400$  *d* aerobic oval spore-forming gram-positive bacillus *B. anthracis* from agar slant  $\times 1400$ \*

suppurative tenosynovitis. They are almost always introduced through a wound of the tendon sheath such as is made by a pin prick through a flexion crease.

The clinical manifestations of the different diseases produced by the hemolytic streptococci are so varied that many attempts have been made to find some cultural or biologic activity to account for the differences, but most of these artificial classifications have been without clinical significance, with the exception of Lancefield's.<sup>4</sup> She has been able to place almost all of the

little difference between the streptococci which form green colonies on blood agar plates and those which have no effect on the red cells. Such organisms produce lesions which are even more varied in their clinical manifestations than those produced by the hemolytic streptococci. They are usually associated with the respiratory or intestinal tract. Non-hemolytic streptococci are normal inhabitants of the mouth and are present but are less numerous in the

\* Meleney: The Bacteriological and Immunological Aspects of Surgery. Nelson's Loose-Leaf Surgery.

nasal passages. They are frequently the chief offenders in the formation of abscesses around the teeth or of abscesses in the cervical lymph glands following dental infections. They are apparently able to resist the destructive action of the gastric juice, for they are frequently present in the upper duodenum; and when a perforation develops in that portion of the intestinal tract, they

clearcut. They may frequently be cultured from the contents or the wall of an inflamed gallbladder and share with *Bact. coli* and *Bact. typhosum* the responsibility in the production of infectious cholecystitis and cholelithiasis. In association with *Bact. coli* they may also produce liver abscesses. Apparently they have a symbiotic role in the severe infection known as Vincent's angina, in which

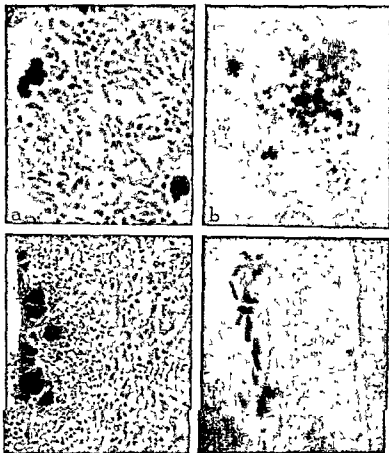


Fig 7.—a, Colony of gram-negative bacilli in the wall of the bladder; *B. mucosus capsulatus*,  $\times 1400$ , b, colony of staphylococci in the prostate gland  $\times 1400$ , c, masses of staphylococci in an infected thrombus; d, colony of *C. welchii* in striated muscle. One oval spore is seen.\*

are frequently found in pure culture in the peritoneal exudate. They are present in the intestinal tract in increasing numbers from above downward and are commonly found in the peritoneal exudate when the appendix perforates. They may occasionally pass through an inflamed appendix wall without perforation.\* They are found in large numbers in the exudates in cases of ulcerative colitis, but it has not been proved that they are the etiological factors. Similarly, it has been claimed that they produce gastric and duodenal ulcers, but the evidence is not

the spirochetes and fusiform bacilli from the mouth play an active part. Likewise, they are frequently found in infections which follow animal bites or human bites. Like the hemolytic variety they may contaminate accidental wounds and cause infections in them.

(B) *Staphylococci*.—Surgical infections caused by staphylococci are more numerous than those caused by streptococci, but in general they are less serious. *Staphylococci*

\* Meloney. The Bacteriological and Immunological Aspects of Surgery, in Nelson's Loose-Leaf Surgery



have been significantly classified according to their pigment formation and less significantly according to their power to hemolyze blood

Staphylococci are more resistant to control with the sulfonamide drugs than are the hemolytic streptococci partly owing to the fact that they characteristically produce early necrosis of tissue which interferes with the action of these drugs. Sulfanilamide has practically no effect on these organisms. Sulfathiazole on the other hand has been able to reduce the mortality of staphylococcal septicemia to an appreciable degree and probably has been able to prevent septicemia in severe local infections with these organisms.

**Bacteriophage**—Staphylococcal infections frequently respond to the local application or general administration into the blood stream of staphylococcus bacteriophage. The *Staphylococcus aureus* group of organisms constitute one of the few groups which respond favorably to this type of therapy because phages are available which are potent against a wide variety of strains. Success depends upon using a phage which is potent for the organism causing the infection preferably one which passes the double potency test that is it will not only clarify by lysis a turbid suspension of organisms in liquid medium but will not permit growth when the cleared culture is transplanted to a blood agar plate. In the treatment of local staphylococcal infections it should be administered daily with a blunt hypodermic needle into the center of the lesion. Usually within twenty-four hours there is subsidence of the spread and thereafter rapid liquefaction of slough and resolution of the infection occur obviating the necessity for surgical treatment. Tissue which has been killed prior to the application of the phage will of course have to liquefy and come away either as a core (slough) or as pus. Occasionally this is facilitated by a small incision.

In the treatment of staphylococcal septicemia "doubly potent" phage should be given intravenously as soon as the diagnosis is made starting with 1 cc and increasing by 1 cc increments at hourly intervals up to 5 cc thereafter with 2 cc increases every four hours up to 25 cc. Treatment should

be continued until the blood culture has been negative on alternate days and the temperature is maintained below 102° F.

**Penicillin**—In 1929 Fleming reported inhibition of growth of staphylococci on an agar plate by the action of some widely diffusing substance produced by the mold *Penicillium notatum*. Since then the extract from the products of this organism has been purified and made available for clinical use. Its chief value has been demonstrated to be in the control of pure staphylococcal infections including septicemia except in cases in which such infection has become established on the heart valves. Certain other organisms are susceptible to penicillin including most of the gram positive but in surgical infections its outstanding benefits have been obtained in staphylococcal lesions and in field in which the sulfonamides have been disappointing. Penicillin has a further advantage over the sulfonamides in that it is almost completely lacking in toxicity. Furthermore its action is not inhibited by the presence of broken-down tissue, blood or pus. Its chief shortcoming in the treatment of surgical infections is the fact that it is inhibited by the presence of many of the gram negative bacilli which may limit its usefulness for war casualties and civilian wounds.

**1 Staphylococcus aureus**—Organisms of this type are found commonly on the skin and may be able to live and grow in the ducts of the sweat and sebaceous glands. They are frequently present in the nasal passages but more rarely in the mouth and alimentary tract. Apparently they can survive for a long time on dust particles in the air. They produce a yellowish brown pigment in the colony when grown on solid artificial media and vary considerably in their hemolysis on blood agar plates. *Staphylococcus aureus* is the common organism present in localized inflammatory processes of the skin such as furuncles and carbuncles. It occasionally produces an abscess around a tooth and is almost the sole cause of suppurative parotitis. Rarely yellow staphylococci enter the body through the lungs and produce pneumonia and empyema but this is usually a sequela of septicemia. They exceed streptococci in the frequency of causing clean wound infections probably be-

cause they are invariably introduced from the surface of the skin itself. There is no seasonal incidence of staphylococcal infections as there is with streptococcal infections. From infected wounds they frequently spread via the veins or lymphatics into the general circulation and produce septicemia with metastatic abscesses in various organs or tissues of the body. In such cases either suppurative thrombophlebitis of the small vessels in the wall of the local lesion or in the neighboring veins or lymphatics or vegetative endocarditis is usually found at autopsy. Staphylococci seem to have a special predilection for bone especially in young children. They may enter the body through a pimple or a trivial wound and produce a violent reaction resulting in extensive destruction of the bone marrow cavity.

2 *Staphylococcus albus*.—These organisms produce white colonies on agar plates which may or may not be hemolytic. They are extensively distributed in nature being found in the same localities on and in the human body as *Staphylococcus aureus*. Usually the lesions produced by them are milder than those caused by the yellow staphylococci. These organisms are most frequently found in small pimples and boils and in the trivial infections which occasionally occur in clean operative wounds. They rarely produce septicemia or osteomyelitis.

(C) *Pneumococci*.—The surgical diseases produced by this group of organisms are generally associated with either a pleural or a peritoneal infection. With less rapidity than the streptococci these organisms pass through the lung and infect the pleural exudate which develops to a variable degree in practically all cases of pneumonia. Frequently this pleural exudate remains sterile but if pneumococci can be cultured from it the condition generally develops into a surgical rather than a medical problem. Then a careful study of the individual case is required in order to decide whether and when to use surgical measures for relief. From the pleura pneumococci may spread to the pericardium and there produce a suppurative process which will require surgical therapy. When the organisms invade the blood stream they not infrequently localize in the joints or in the meninges. The former condition requires surgical treatment and the

prognosis is good but localization in the meninges was previous to the advent of sulfapyridine almost invariably fatal. This drug was soon found to have an almost miraculous curative effect on pneumococcal infections not only of the lungs but of the meninges. Sulfathiazole has more recently been found to be able to duplicate these results in pulmonary but not in meningeal infections due to the pneumococcus. In a few cases an attempt has been made to introduce a specific antipneumococcus serum into the ventricles by operative means but success in such a procedure is rare.

Surgeons are particularly interested in pneumonia following an operation. This is more likely to occur in a patient who has recently had a cold than in one who has not. It is also more common following upper than following lower abdominal operations. Apparently a number of factors—mechanical and chemical as well as infectious—are at play in the production of these lesions. Frequently a plug of mucus blocks a bronchus and produces an atelectatic area which becomes susceptible to bacterial infection. The lack of aeration in the bases of the lungs due to pain on deep breathing after an upper abdominal operation favors the closure of the small bronchi in the lower lobes. Cutler and Hunt<sup>1</sup> however have stressed the importance of the role of emboli which come from the operative field and produce small pulmonary infarcts which are subsequently infected. The importance of postoperative pneumonia has appreciably decreased since the advent of sulfapyridine and sulfathiazole.

Since pneumococcal infection of the peritoneum is four times as prevalent in females as in males the fallopian tubes have been considered to be the portal of entry. However some of these cases follow frank pneumonia and then the source of infection is almost certainly extragenital. Occasionally an ovarian cyst becomes infected with pneumococci. Here the portal of entry is uncertain.

(II) *Gram Negative Cocci*. (A) *Gonococci*.—The activity of these organisms comes within the scope of surgery largely through errors in diagnosis. Operations are often performed in cases of acute peritonitis suppurative arthritis suppurative teno-

synovitis or epididymitis because it is impossible to tell before a culture of the exudate has been made whether the infectious agent is the gonococcus or some other organism. Since gonococcal lesions usually subside spontaneously, these operations are futile and probably harmful although in many instances they are justifiable. The response of these infections in both acute and chronic forms to sulfathiazole has largely taken them out of the field of surgery.

Penicillin is particularly potent against the gonococcus even when the organism has become resistant to sulfathiazole or sulfadiazine. A few (five or six) injections intramuscularly of 10 000 to 15 000 units every three hours will rid the genital tract of these organisms rapidly and usually permanently. Occasionally a second series of injections must be given if there is recurrence of symptoms. When joints are involved penicillin associated with fever therapy is required to control the infection.

#### B. AEROBIC BACILLI

(I) *Gram Positive Bacilli* (1) *Bacillus tuberculosis* from a surgical point of view is by far the most important of the aerobic bacilli. It may attack any organ or tissue of the body and in that respect is more ubiquitous than any other organism. Fortunately in this country surgical tuberculosis has gradually become more and more rare as a result of improved hygienic conditions and an appreciation by the patient developed by popular education of the importance of treating the disease in its early stages.

The tubercle bacillus usually enters the body through either the respiratory or the alimentary tract and frequently lodges in the cervical and mesenteric lymph glands. In the former instance the tonsils are frequently found to be infected and require surgical removal.

Milk as a source of the bovine type of tubercle bacillus has been practically eliminated in many states by the testing of herds and the destruction of tuberculous cattle.

Twenty five years ago it was common surgical practice to remove tuberculous cervical lymph glands by excision. Today this procedure is required in a much smaller number of cases chiefly because the disease

occurs less often but also because some cases respond favorably to x-ray treatment or to heliotherapy. Tuberculosis of the mesenteric lymph glands occasionally necessitates surgical removal particularly when the glands become calcified and incapacitate the patient because of continued severe abdominal pain. Pulmonary tuberculosis has however come within the scope of surgery because of the successful work of Sauerbruch in Germany and a number of other surgeons in Europe and America. A plastic operation is performed on the chest which permits the diseased lung to collapse and enjoy more or less complete physiologic rest. Thoracoplasty can be performed when only one lung is involved in carefully selected types of cases.<sup>6</sup> (See section on Surgery of Pulmonary Tuberculosis.)

Tuberculosis of the intestinal tract is generally limited to the lower ileum and cecum but other portions of the tract may be involved. These cases occasionally require excision or short circuiting but many of the patients respond to a prolonged hygienic regimen including rest and heliotherapy.

Tuberculosis of the peritoneum frequently becomes a surgical problem usually because of the difficulty of making a differential diagnosis. Often it cannot be distinguished from other diseases accompanied by a cecus particularly cancer unless an exploratory operation is performed. If the focus is abdominal and can be removed without great risk such a procedure is justifiable. Tuberculosis of the genitourinary tract is usually secondary to foci elsewhere.<sup>7</sup> Frequently however the primary focus is small or quiescent and it may be wise or urgently necessary to remove the secondary focus. This is often a relatively safe and successful procedure in tuberculosis of the kidney but it is more difficult in tuberculosis of the epididymis or of the bladder.

Tuberculosis of bones and joints is still fairly common in children. It is of course hematogenous in origin and must therefore have a primary focus elsewhere. Surgical fixation of such lesions is frequently indicated.

(B) *Bacillus anthracis*—(See section on Anthrax.)

(C) *Bacillus diphtheriae* is of interest to the surgeon only because at times it may

be found as a contaminating organism in wounds and chronic ulcers which fail to heal Grossmann examined four hundred open wounds and found the true diphtheria bacillus in 5 per cent of them Some of the wounds healed promptly after the administration of diphtheria antitoxin

(D) *Diphtheroid bacilli* constitute a heterogeneous group of gram positive organisms They are pleomorphic often becoming coccoid or assuming bacillary forms which vary considerably in size and shape They are frequently found in the air and occasionally on the skin and in swollen lymph glands They are common inhabitants of the intestinal tract and are found in peritoneal exudates when there has been intestinal perforation Occasionally these organisms seem to be able to produce a trivial infection in clean operative wounds and may grow out in pure culture when the other contaminating organisms fail to do so

(E) *Bacillus subtilis* is of the same significance to surgeons as the diphtheroid bacilli except that it is not often found in peritoneal exudates It is a spore forming organism of low pathogenicity which may be used satisfactorily as a test organism in determining the efficiency of any sterilization process

(II) **Gram Negative Bacilli**—Gram negative bacilli have become increasingly important in recent years since penicillin has been available for clinical use Many of the gram negative organisms produce a substance which renders the penicillin inactive and when present in a mixture of bacteria as in burns or accidental wounds may interfere with the therapeutic effect of penicillin

(A) *Bacterium coli* represents one of the most widespread groups of bacteria These bacilli are found almost universally in the intestinal tracts of man and animals appearing in the stools shortly after birth and remaining there throughout life Although they live within the intestinal tract they apparently do no harm to the host However when they are introduced into other tissues and organs they may cause profound illness and death With the constant trauma to the mucous membrane of the intestines from indigestible food particularly in the appendix and in the lower sigmoid and rec-

tum where the feces are inspissated the door is open for the entrance of these organisms into the deeper tissues Thus *B coli* may be carried to the neighboring lymph glands or to the liver From the liver it may be carried to the gallbladder by way of the bile or it may reach the gallbladder by passing up the *choledochus* Being discharged in large numbers with the stool it naturally contaminates the area around the anus and frequently may be introduced into the vagina and urethra of females especially infants Owing to the difficulty of sterilizing these parts it is almost invariably introduced into the bladder during catheterization and it is the commonest organism found in either the spontaneous or postoperative cases of cystitis and pyelitis

*Bacterium coli* is of interest to the surgeon chiefly because of its association with appendicitis and cholecystitis It may not be the primary cause of appendicitis but when the organ becomes inflamed *B coli* may pass through the grossly intact wall produce peritonitis and be recovered from the exudate in pure culture<sup>8</sup> The other intestinal organisms seldom do this but if perforation takes place some representatives of all of the bacterial species present in the intestinal tract are discharged into the peritoneal cavity and may play a part in the subsequent infection<sup>9</sup> In like manner when the intestinal wall is perforated by any ulcer or by a foreign body *B coli* plays a major role in any subsequent infection If the organisms then spread via the portal venous radicles to the liver multiple abscesses may form *B coli* reaches the gallbladder either from the liver via the bile or by passing up the duct It may precede or follow the development of stones but it usually shares with *B typhosus* and the non hemolytic streptococcus the infective role in the development of cholecystitis<sup>10</sup>

(B) *Bacillus typhosus* is of interest to the surgeon chiefly because of its relationship to certain complications of typhoid fever The chief of these are perforations of the intestine and cholecystitis Occasionally subperiosteal abscesses appear in the long bones and more rarely abscesses develop in the subcutaneous tissue elsewhere

Ulcerations of the intestines leading to perforations are almost certainly due to the inflammatory process

in Peyer's patches of the lower ileum. When perforation takes place not only the typhoid bacillus but all of the intestinal organisms are introduced into the peritoneal cavity. In such cases only prompt operation and closure of the perforation will prevent death. Frequently during the course of typhoid fever the patient complains of symptoms in the region of the gallbladder but in many cases there are no subjective signs until years after and then the mechanical factor of gallstones calls attention to the fact that a pathologic condition is present. In such cases the typhoid bacilli may be found in the stool but they usually disappear after removal of the gallbladder. In a few cases the organism establishes itself permanently in the liver or in the intestinal tract and the patient remains a carrier and a menace to society for life. Potentially bacteriophage in the body of such an infectio-

erious with chronic infections in the neighborhood of the alimentary canal especially gangrenous processes. Some investigators have insisted that it is the cause of such infections but it is usually merely a secondary invader and of little concern to the surgeon. A few authentic cases have been reported however in which it seemed to be pathogenic. In one case it apparently produced a thrombophlebitis of the jugular vein in the peritonsillar region. The clot propagated itself back to the brain an abscess formed and the process spread with the blood stream as well producing an abscess of the lung.<sup>1</sup>

(C) *Bacillus mucosus capsulatus* was originally thought to be the chief cause of lobar pneumonia but its occurrence in such cases is relatively rare. Its chief interest to the surgeon is due to the fact that it causes serious complications in certain diseases of the respiratory and alimentary tracts. Empyema or abscess of the lung in which this organism is found is almost invariably serious. This organism is rarely found alone in peritoneal exudates but when perforation has occurred and the organism has established itself with others in the peritoneal cavity it stubbornly resists all efforts to eradicate it. Not infrequently it is carried off to the liver and there it produces one or more abscesses which are almost always fatal.

(D) *Bacillus pyocyaneus* is ordinarily considered to be non pathogenic but it frequently is most annoying as a secondary contaminant in chronic infections especially those associated with the alimentary canal in which it is commonly found. The characteristic appearance and odor of the green pus indicate its presence and demand special measures to insure its removal. It is often extremely resistant to eradication and occasionally invades the deeper tissues. It has frequently been found in the blood stream. In such cases it rarely if ever produces metastatic foci and generally disappears from the blood when vigorous efforts are made to remove it from the portal of entry. When it occurs in a postoperative infection in a previously clean wound a serious complication usually results (Table 1).

(E) *Bacillus proteus* is frequently asso-

(F) *Hemophilus influenzae*—The role of this organism in infectious diseases particularly of the respiratory tract is still a moot question but a few authentic cases make it necessary for the surgeon to remember that the organism may at times produce suppurative pleurisy which requires surgical attention.

(G) *Bacillus mallei*—With disappearance of the horse from every day contact with man the surgical significance of *B. mallei* has steadily declined. The surgeon must remember however that this organism can produce serious lesions of the skin and of the subcutaneous tissues resembling the lesions of staphylococci or of anthrax which may be either extremely chronic or exceedingly acute and fatal.

## II ANAEROBIC BACTERIA

Pasteur made the observation in his early bacteriologic studies that certain organisms grow only in a medium from which the air has been excluded.<sup>1</sup> Such organisms were called anaerobic bacteria and it was assumed that oxygen was deleterious to their existence.

### A ANAEROBIC COCCI

The only strictly anaerobic cocci of interest to surgeons are gram positive non hemolytic streptococci which are occasionally found in putrefactive processes in the intestinal tract occasionally in foul infections around the teeth and tonsils and in foul lung abscesses. These organisms are not infrequently the cause of puerperal fever and may produce fatal septicemia. They are occasionally found in liver abscesses and in

chronic brain abscesses. They are generally of low virulence and may not be capable of producing disease except in symbiosis with other organisms or when there has been a necrosis of tissue from trauma or from the absence of blood supply.

They fall into two main groups—those which produce a foul odor and gas in artificial media and those which do not. Prevot has attempted a classification of these organisms, but the whole group needs further careful study.

#### B. ANAEROBIC BACILLI

Under this classification there are five species which are of importance to the surgeon. Four of them make up the gas gangrene group, and the other is the tetanus bacillus. Each of these organisms produces a powerful exotoxin which may be specifically neutralized by the appropriate antiserum.

(I) **Gram-Positive Bacilli.**—Practically all of the important gram-positive anaerobic bacilli are spore-forming organisms and, because of this characteristic, have been given the generic term of "*Clostridia*" by the nomenclature committee of the Society of American Bacteriologists.<sup>13</sup>

(A) *Clostridium welchii*.—By far the commonest and most important is the *Bacillus aerogenes capsulatus* of Welch and Nuttall,<sup>14</sup> now called *Clostridium welchii*. It is the common cause of the gas gangrene which reached such enormous proportions in World War I. This organism is almost universally present in the intestinal tract of man and of most animals, just as is *Bact. coli*, but because it forms spores, it survives longer outside of the body and remains for a long time in fertilized soil. The filth of trench life and the frequency of contamination of gunshot wounds with soil and woolen clothing make it readily understandable why gas gangrene was so common among the wounded in World War I. In gunshot wounds this organism was frequently found when there was no evidence of its activity, and it must be considered to be essentially a saprophytic organism which becomes pathogenic only under certain conditions, namely, when it has been introduced in large numbers, when foreign bodies are present or when there has been

considerable destruction of tissue, particularly muscle, which offers it a favorable environment for growth and toxin production.

In civilian life, compound fractures are the precursors of a large proportion of the cases of gas gangrene because of the usually extensive injury to muscles and the contamination of the depths of the wound with street dirt.

*Clostridium welchii* is also of some importance in peritonitis. It rarely passes out through an intact intestinal wall, but if there has been a perforation which has per-



Fig. 8—Muscle fibers destroyed by the action of gas gangrene organisms. Note the paucity of leukocytes.

mitted the escape of intestinal contents, it is able to maintain itself in the peritoneum, although its significance there is not so great as when it is actively growing in muscle tissue.<sup>6</sup> An infection with this organism is characterized by profound intoxication—high fever, rapid pulse, prostration and apprehension. Locally there is pain in the wound, redness, swelling, bronzing of the skin and crepitation, which is due to the generation of gas by the action of the organism on muscle tissue. The extent of the bubbles of gas in the tissues may be accurately determined by taking a roentgenogram of the affected part. When the infec-

tion has become established it travels with great rapidity up the muscle bellies and unless surgical extirpation is promptly applied with or without the aid of serum therapy the patient will almost certainly die.

(B) *Clostridium novyi*<sup>15</sup> (C) *Clostridium septicum*<sup>16</sup> and (D) *Clostridium sordellii*<sup>17</sup> may be listed together as the other gas gangrene organisms. They can be readily distinguished from *C. welchii* by their cultural characteristics and by their neutralization with specific antitoxin. They all produce gas gangrene and are frequently present with *C. welchii* in severe war wounds. When these organisms are present alone the lesions which they produce are edematous rather than gaseous. Crepitation usually cannot be felt unless *C. welchii* also is present. Its presence must always be suspected in wounds contaminated by soil or fecal discharges or when edema or crepitation is present. Infections with gas gangrene organisms are so alarming in the rapidity of their spread and their high mortality that often treatment must be given before the causative organisms can be isolated and classified. The surgical treatment of the various types of gas gangrene is the same and now polyvalent sera are available for use until the causative organism can be identified. Then the specific antiserum should be used. After adequate surgical measures have been used to remove all involved tissues in cases of gas gangrene the wound should be treated daily with a creamy suspension of effective\* zinc peroxide powder suspended in distilled water, care being taken to effect contact with every part of the wound. Although all of the gas gangrene organisms are essentially toxin formers producing true exotoxins which are rapidly disseminated throughout the body they are invasive also and spread extensively in the tissues. But strangely enough only as death approaches or after death is it possible to cultivate these organisms from the blood.

(E) *Clostridium tetani* is also a spore forming gram positive anaerobe but it is less widely distributed throughout nature than the gas gangrene organisms. It is less

often found in the human intestinal tract than *C. welchii* but is fairly common among persons who live in close contact with horses or cattle.<sup>18</sup> Fertilized soil is the commonest source and the organisms must be anticipated in wounds contaminated with soil. As is the case with the gas gangrene organisms *C. tetani* is almost always accompanied by other organisms and the associated organisms generally play a part in the establishment of the tetanus bacillus. Unlike the gas gangrene organisms *C. tetani* does not invade the body; it remains at the site of entrance and produces its toxin which has a selective affinity for nerve tissue and possibly for muscle also. It has been generally accepted for years that the toxin passes up the motor nerves to the cord<sup>19</sup> but Abel and his associates<sup>2</sup> have cast some doubt on this theory. They believe that it attacks muscle directly and passes through the lymphatics to the blood stream and thence to the central nervous system involving especially the motor cells of the cord. The surgical treatment of tetanus is largely prophylactic. The debridement of the wound, the removal of foreign bodies and the scrupulous cleansing of the wound along with the administration of antitoxin are essential. If tetanus has made its appearance complete extirpation of the focus is of utmost importance in order to stop the manufacture of the poison and give the antitoxin the best possible chance to neutralize the toxin already liberated. Tetanus antitoxin is generally indicated as a prophylactic measure in all puncture wounds. (See section on Tetanus.)

(II) Gram Negative Bacilli.—There are a number of anaerobic gram negative bacilli which do not form spores but which are definitely pathogenic. They belong to the bacteroides and necrophorus groups. They are of some importance in symbiosis with other organisms in peritonitis and in chronic ulcerations and are associated with if not the cause of certain forms of chronic ulcerative colitis. The whole group requires further study.

### III MICROAEROPHILIC ORGANISMS

The microaerophilic bacteria form a little known group of organisms which are intermediate between the anaerobes and aerobes. They grow best in an environment

\* At the present time effective zinc peroxide is manufactured only by the Du Pont Chemical Co. and tributed by Merck and by Mallinckrodt.

with a diminished oxygen tension at least when they are first isolated from the human body. They may perhaps be aerobic organisms which have become modified by living for a time in the intestinal tract or in lymph glands. Such organisms are frequently missed with ordinary methods of cultivation or may grow sparsely aerobically. Two types of chronic infections have only fairly recently been recognized as being due to these organisms.<sup>11</sup>

**A Streptococci—Hemolytic microaerophilic streptococci** have been found in pure culture in certain chronic ulcerative non-gangrenous lesions which generally occur on the abdominal wall but which may develop on any part of the body surface. They are characterized by an extensive ulceration with undermining of the skin and the development of sinuses which burrow down between the muscles into the pelvis or groin or into the vulva or scrotum. These infections have in the past existed for months or even years with gradual progression until death ensued as a result either of the erosion of blood vessels or of amyloid changes in the liver, spleen or kidneys. Recently however it has been found that in these cases there is a favorable response to local treatment with zinc peroxide and the outlook in such cases in the future is decidedly favorable.<sup>12</sup> (See section on Chronic Undermining Ulcer.)

**Non Hemolytic Microaerophilic Streptococci**—Similar organisms which are not hemolytic but which tend to produce met-hemoglobin on blood agar plates have been found in very chronic gangrenous lesions of the abdominal or chest wall following the drainage of peritoneal or pleural abscesses. The lesion is extremely painful and spreads slowly with a zone of adherent gangrenous slough without extensive undermining and burrowing or the formation of sinuses such as occur in the condition described above. Outside of the zone of gangrene there is a raised purple necrobiotic zone and beyond this is a red hyperemic zone in which the organism can be found in pure culture. In the gangrenous zone it is always associated with a staphylococcus. This disease seems to be a synergistic infection in which the streptococcus which alone is apparently non-pathogenic in some way paves the way for

the gangrenous action by the staphylococcus.<sup>21a</sup> (See section on Chronic Gangrene.)

#### IV SPIROCHETES

The *Treponema pallidum* of syphilis can hardly be said to cause surgical infections although syphilitic lesions are frequently operated on when there has been a mistake in diagnosis. On the other hand some of the spirochetes such as *T. macrodentium* and *T. microdentium* and spirilla of the mouth frequently find their way into dental abscesses which may spread to the cervical lymph glands or to the lungs and produce foul smelling abscesses. They frequently occur also in foul infections of other parts of the body especially of the hands following human bites. Such cases are helped by the intravenous administration of neo-salvarsin but frequently surgical drainage or amputation is also required. Zinc peroxide is usually effective in eradicating these organisms in foul smelling dental infections and human bites.

#### V HIGHER MICRO ORGANISMS

**A ACTINOMYCETES**—(See section on Actinomycosis.)

**B BLASTOMYCETES**—(See section on Blastomycosis.)

**C COCCIDIOIDES**—(See section on Coccidioidal Granuloma.)

**D SPOROTRICHIA**—(See section on Sporotrichosis.)

#### POSTOPERATIVE SURGICAL INFECTIONS

In the second part of this section the factors have been discussed which favor or minimize contamination of an operative wound. There are also certain disturbances of the normal physiology which occur during or after an operation which favor the establishment of infection in other parts of the body. These affect chiefly the respiratory, alimentary or urinary tract.

**A Respiratory Postoperative Infections**—During almost all general anesthetics and to a less extent with the action of sedatives or narcotics preliminary to local or spinal anesthesia there is diminution or suppression of the cough reflex. Frequently a particle of mucus or food or a drop of water enters the larynx and trachea in a normal



person who has not received any medication. It almost invariably starts a violent coughing attack which quickly dislodges the particle and frees the trachea from the offending substance. On the other hand it has been found that non-irritating substances such as oils may run down into the larynx without starting the coughing reflex. Certain inhalation anesthetics cause increased ventilation and increased depth and force of respiration favoring the entrance of mucus into the trachea and bronchi.<sup>19</sup> With almost any anesthetic it may be assumed therefore that organisms and mucus from the mouth and sometimes blood become lodged in the respiratory tract below the glottis—the position being determined by the depth of the anesthesia, the size of the particle and the other factors previously mentioned. Furthermore sedatives, narcotics and anesthetics as well as pain limit the excursion of respiration and lessen the aeration of the lungs. Small bronchi or bronchioles particularly in the bases of the lungs then become shut off and the air in the alveoli which they supply becomes absorbed. Atelectasis results and if organisms are present the opportunity is given for them to multiply and produce their poisons. If they are sufficiently virulent to resist the phagocytic action of the lining cells they may destroy the cells and invade the tissues producing bronchitis, lobular or lobar pneumonia or occasionally pulmonary abscess. The pneumococci which are frequently present in the mouth are the organisms most likely to produce these infections especially the pneumonias but the other organisms also may play a role in the bronchitides and lung abscesses. The latter conditions frequently reveal the presence of anaerobic or microaerophilic streptococci or the oral spirochetes and fusiform bacilli. Sometimes bacteria are conveyed to the lungs in pulmonary emboli from infected foci. Even if sterile an embolus may produce an abnormal area in the lung which favors the establishment of organisms introduced from above. If the embolus is germ laden infection almost inevitably develops.

Efforts should be directed to minimize the occurrence of these infections. In certain operations the anesthetist may maintain the anesthesia at a level which does not completely

obliterate the cough reflex. Use of CO<sub>2</sub> and O<sub>2</sub> inhalation after operation has been advocated to increase the amplitude of respiration and to free the bronchi from accumulated mucus. Binders which limit the movement of the lower ribs should be avoided and every effort should be made to restore the normal physiology as soon as possible. Attempts have been made to minimize the bacterial content of the mouth and throat before operation by the use of various antiseptics but so far none has proved efficacious. Further efforts should definitely and constantly be made in this direction until something has been found which will readily diminish the number of postoperative respiratory infections. When they occur they readily respond in most instances to appropriate doses of sulfadiazine or sulfathiazole.

**B. Alimentary Postoperative Infections.**—Occasionally postoperative tonsillitis develops following inhalation anesthesia but only rarely after rectal or local anesthesia. Almost always the organisms which are active in these cases were present in the patient's throat before operation but occasionally they are introduced if a tube or metal airway is used. These objects may traumatize the tonsils and the churning of the pharyngeal mucus may favor the invasion of the organisms. Postoperative parotitis is a distressing complication of frequent occurrence in debilitated persons. It seems to be favored by dryness of the mouth. The offending organism is almost always the hemolytic *Staphylococcus aureus*. The organism probably reaches the gland by way of the duct although it is surprising that other organisms more common in the mouth do not occasionally cause parotitis. One can only surmise that the parotid gland is particularly susceptible to the staphylococcus. The esophagus, stomach and duodenum are not often affected by bacterial invasion after operation. Paralytic or mechanical ileus however may have a bacterial element. The stasis of intestinal contents inevitably causes retention of irritating substances both chemical and bacterial in contact with the mucous membrane which is stretched by the accumulation of gas and compromised by a diminished blood supply. The amount of absorption from intestinal

distention has been a matter for debate and experimentation. The facts are little known but the possibility of a large bacterial factor in the production of clinical symptoms can not be denied. The frequency of rectal irritation from the mechanical apparatus used to overcome postoperative distention occasionally favors invasion of the perirectal tissues by intestinal bacteria with subsequent abscess formation. This possibility should always be borne in mind and rectal treatments should not be continued longer or carried out oftener than is absolutely necessary.

**C Urinary Postoperative Complications**—Frequently after an operation in the lower abdomen or on the pelvic floor or perineum the reflex spasm of the sphincter of the bladder prevents evacuation and results in retention of urine and distention of the bladder. This may become so painful that it must be relieved by catheterization. It is difficult if not impossible to sterilize the meatus of the urethra and consequently any instrument is certain to carry organisms into the upper urethra or the bladder. If distention occurs again or if the bladder fails to empty completely the organisms may be retained; they may grow in the urine and invade the bladder wall. They may invade the ureters also either by entering the meatus and infecting the urinary column or by passing up in the wall. Thus pyelitis or pyelonephritis may develop. Infection occurs in a large percentage of patients who require catheterization. The organisms most often found are the *Bact. coli* and intestinal green streptococci both of which apparently grow readily in urine. Obviously catheterization is to be avoided if possible and always performed with the utmost care in order to minimize the introduction of organisms. It is also important to prevent the collection of residual urine and to remove speedily the contaminating organisms before they can gain a foothold. When they are once established it is difficult to eradicate them but this may be done by assiduously flushing the bladder with all kinds of diuretics alternating with acidifying antiseptics or if that fails by the use of an appropriate and potent bacteriophage. Recently sulfathiazole has been found to be effective against certain strains but it is ineffective against others. When given by mouth it is elim-

inated through the kidneys if they are not diseased in sufficient concentration to inhibit the growth of the organisms materially.

#### HOW DO BACTERIA ENTER THE BODY?

The human body is covered by a layer of hornified epithelium of varying thickness which is punctured by the ducts of the sweat and sebaceous glands and by the hair follicles. At the orifices of the body the skin joins with mucous membrane which lines the inner surfaces of the alimentary, respiratory and genitourinary tracts and the conjunctival surface of the eyes. On the surface of the mucous membrane the ducts of various glands pour out secretions: saliva, mucus, bile, gastric and pancreatic juice, urine and various minor glandular secretions of the respiratory and alimentary tracts. Bacteria cannot penetrate the horny layer of the skin but certain species such as the staphylococci are able to live in the ducts and may at times grow there and produce poisons. Such toxic products may then have the power to destroy the thin layer of epithelium lining the duct and permit the organisms to enter the subepithelial layers. Organisms which cannot grow metabolize and produce lytic substances on or in the skin must await some mechanical force to transplant them into the deeper layers. On the surface of the mucous membranes particularly of the alimentary tract are substances which can be utilized by a large number of bacterial species for food which will permit them to grow and metabolize and give off poisons or waste products which may injure the surface epithelium. At the same time the inner surfaces of the body are subject to minor injuries which carry the surface organisms into the deeper tissues. It may be said in general that bacteria usually enter into the subcutaneous tissues through breaks in the continuity of the skin rather than through an erosion of the surface by bacterial products and bacteria enter the subcutaneous tissues through the erosion of the surface by bacterial products rather than through wounds. Furthermore there are certain physiologic changes in the surface of mucous membranes which may render them liable to the invasion of bacteria. For example the congestion that occurs in the nasal mucous membrane in response to mu-

chemical or thermal stimuli renders it more permeable than when it is not congested. Similarly in the genital tract the lining of the uterus after menstruation or parturition is more liable to penetration by organisms than it is normally. The congestion of the mucous membrane of the urethra during intercourse probably renders it more permeable to gonococci than it would be normally. In the alimentary tract there is always a certain amount of indigestible material which may traumatize or puncture the mucous membrane and permit organisms to enter. It is generally believed however that typhoid, cholera and dysentery organisms as well as the tubercle bacillus may pass through an intact intestinal wall. Any obstruction to the onward flow of the intestinal contents increases the possibilities of mechanical and chemical injury because of the greater time of contact of the irritating substance and because of the pressure exerted on the intestinal wall by the accumulated fecal fluid and gases. This may result in the cutting off of the blood supply so that the surface cells may die, disintegrate or be torn apart.

#### How Deep Must a Wound of the Skin Be to Permit the Entrance of Organisms?

—The basal layers of the epidermis consist of round or polygonal cells which have normal nuclei and are connected to neighboring cells by cellular bridges. No blood vessels enter the epidermis but there is a circulation of lymph beneath the bridges which nourishes the cells for the first few layers. Higher up the cells become smaller and flatter they begin to lose their nuclei and they become packed closely together. Still higher they lose their nuclei and become completely keratinized. Any cut or abrasion which penetrates to the layer around which fluid is circulating may carry organisms into these intercellular spaces. They may then be carried off in the current directly or may lodge in these spaces, colonize and produce poisons which erode capillaries or lymphatics and pave the way for deeper penetration by the organisms.

#### HOW DO BACTERIA SPREAD WITHIN THE BODY?

When bacteria pass the first barrier either because they have produced an erosion or

because they have been carried in through a wound they reach the subepithelial tissues. If purulent discharges have been introduced directly from another human source the dose of organisms may be large and accompanied by toxic products which may injure the tissue cells at once. Usually however the dose is small and the organisms have come from an entirely different environment. If they are to produce an infection the organisms must maintain themselves in the face of hostile forces, namely the tissue fluids, the blood and the phagocytic cells. As a rule the bacteria are promptly destroyed but if a few survive they will presently begin to multiply. Finally a colony of organisms is produced and the waste or toxic products accumulate. If these products are fluid they may diffuse outward in all directions. The fluid may attract or repel leukocytes and according to its concentration may be destructive to the neighboring tissues and cause liquefaction thus producing a little fluid space around the colony. Organisms may then be carried away from the surface of the colony by the currents of fluid circulating about the colony. These organisms will be stopped for a while however by some intercellular fibrils or by the endothelial lining of capillaries or lymphatics. As the lymphatic system is closed they cannot enter the lymphatics directly. They may however be picked up by the wandering cells of the blood or by the endothelial phagocytes and may be destroyed or carried into the capillaries or lymphatics. If phagocytosis does not take place the organisms may multiply and produce a new colony at a distance from the parent colony. The whole process perhaps being repeated there. The bacterial products besides liquefying tissue frequently cause thrombosis of capillaries and then there may be subsequent invasion of the clot by the liquefaction of the lymphatic or capillary wall. As the clot increases in size within the vessel the bacterial invasion follows until the next larger vessel is reached. Then this radicle may become thrombosed or pieces of the infected clot may be thrown off into the lymph or blood stream and carried to the next narrow portion of the capillary bed either in the lungs or the liver. If there are individual organisms or bits of blood clot

which are smaller than the capillaries, they may pass through the lungs to the pulmonary veins and then, coursing through the heart, may be thrown off into the arterial side and caught in the peripheral capillary network or destroyed in the blood. If caught, they may again start a metastatic colony with a repetition of this process until death ensues. For further details regarding these interesting processes of infection the reader is referred to Zinsser's book<sup>22</sup> and to the author's chapter in Nelson's Loose Leaf Surgery.<sup>11</sup>

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## CHEMOTHERAPY IN SURGICAL INFECTIONS\*

### INTRODUCTION

Until 1935 the term chemotherapy was largely limited to the topical use of antiseptic agents in wounds. It has been only since then that chemotherapeutic agents effective in the sense that Paul Ehrlich first used the term have become available. Ehrlich coined this term to signify the destruction of special disease-producing living agents within the body of the diseased being but in practical usage the term has been limited to the employment of agents which may be administered systemically which will retain their activity against bacteria in the body and which will be transported by the circulation to the site of the infection and there provide a direct attack on the bacterial parasites. It is probably desirable to continue to apply the term antiseptic to agents which may be used only in sterilization of skin or in topical antibacterial therapy of open infected wounds.

In attempting to discover drugs which would aid the animal host to combat infection Ehrlich faced a problem of great complexity but he approached it with decided ingenuity. In the treatment of infections he was impressed by the possible usefulness of the aniline dyes which were originally introduced by his cousin Weigert for selective staining of bacteria in the tissues. Ehrlich reasoned that a dye which could selectively stain bacteria in the tissues might also produce a selective toxic effect on these bacteria. In pursuing this quest Ehrlich pushed aside the pessimistic attitude toward chemotherapy which prevailed at the opening of the 20th century. His distinguished contemporary von Behring had said: "It can

be regarded almost as a fact that the tissues of man and animals are many times more susceptible to the poisonous effects of disinfectants than are any of the bacteria known at present therefore before the antiseptic has a chance either to kill or to interrupt the growth of the bacteria in the blood or in the organs of the body the infected animal itself will be killed. The pessimism of him who declared that disinfection in the living body is for all times impossible appears to be only too justified. Actually Ehrlich never succeeded in developing a drug which could be used in the treatment of bacterial infections in man. He did show that trypan red was a drug effective in combating experimental trypanosomal infection of mice and subsequently he made his brilliant discovery of salvarsan which revolutionized the management of syphilis and very significantly prepared the ground for the discovery of sulfonamides by his fellow countryman Domagk in 1933.<sup>1</sup>

**Sulfonamides**—It is of interest that the first sulfonamide drug, prontosil, was a red dye of the so-called azo type formed through the combination of *chrysoidin* with sulfanilamide. Sulfanilamide had been synthesized in 1909 but for more than twenty years it was employed only in the dye industry as a means of increasing the fastness of aniline dyes for wool protein. Apparently the German workers were not aware of the fact later brought to light by the French investigators Monsieur and Madame Trelovel that the effectiveness of prontosil was due to the sulfanilamide in the molecule and that the *sulfanilamide split off from the dye* as a result of the action of enzymes in the body fluids and then circulated in free and active form. This explained the interesting fact that prontosil itself was inactive in the test tube whereas sulfanilamide enjoyed a very considerable degree of activity against certain types of bacteria *in vitro*.

Considerations of space do not permit including in this chapter a detailed account of the historical development of the sulfonamide drugs. It is important however to call attention to the major contributions of Leonard Colebrook and his colleagues<sup>2,3</sup> in defining the possibilities and limitations of sulfonamides in the treatment of one type of severe hemolytic streptococcus infection.

\* The growing importance of chemotherapy in the prevention and treatment of surgical infections has led to the preparation of this special section on the subject. Obviously it would be impossible within such limits to present all of the subject matter on chemotherapy which should be understood by individuals engaging in the administration of these drugs. It is the purpose of this section simply to offer a broad view of the field and as far as possible to supply the rational basis for selection and administration of the drugs in the principal types of surgical infections. The bibliography includes a number of publications to which the student is referred for supplementary reading.

namely puerperal sepsis Colebrook was responsible for the following observations. First after treatment with prontosil or sulfanilamide the blood of the patient became rapidly endowed with the capacity of killing many times the number of hemolytic streptococci that would be killed by the blood of a normal subject or the blood of an infected patient prior to receiving the drug. This served to explain in a general way why the sulfonamides were effective as chemotherapeutic agents. Second he observed that the bacteria were not all destroyed in the body by the action of the drug and he correctly inferred that the major role of the sulfonamides was to interfere with the ability of hemolytic streptococci to multiply in the body but that the actual clearing of bacteria from the infected area occurred through the continued operation of the immunity mechanisms of the patient. He pointed out that sulfanilamide treatment was most effective in dealing with the true invasive factor in hemolytic streptococcal infections namely the multiplication of streptococci in blood and in tissues of fairly normal architecture. It was later observed by American workers<sup>4</sup> that the use of sulfonamides in the body was limited in proportion to the amount of breakdown of tissue which occurred at the site of the infection and that necrosis and suppuration in the infected area resulted in liberation of substances which were specifically antagonistic to sulfanilamide both in the body and in the test tube as well. These fundamental principles developed by Colebrook and others have continued to apply to the field of sulfonamide therapy even in the face of the development of many new drugs enjoying a range of activity far greater than that of sulfanilamide itself. By 1942 both sulfathiazole and sulfadiazine had been discovered and had been found to be effective not only against most streptococcal infections but against pneumococcal meningococcal and gonococcal infections as well with the use of these drugs it appeared that mortality rates from peritonitis and from infection in accidental wounds would be significantly reduced and the attitude expressed by von Behring in 1904 had been replaced by a sense of confidence that still newer drugs would be found which would

have curative action in all types of bacterial infections.

The sulfonamides are limited in their usefulness in surgical infections in several important ways. In the first place most of the so called surgical infections are characterized at some stage in their development by the presence of a suppurating focus of infection in soft tissue or bone. If the sulfonamide is administered at a sufficiently early stage in the development of the infection namely before tissue breakdown has occurred through action of bacterial enzymes and interference with blood supply the further progress of the lesion may be checked however once breakdown of tissue has occurred the drugs are incapable of effecting the further destruction of bacteria in the focus and it becomes necessary to resort to surgical methods of eradicating the lesion. The next important limiting factor of sulfonamides in the treatment of surgical infections derives from the comparatively low degree of activity of sulfathiazole and sulfadiazine on the *Staphylococcus aureus*. The overwhelming majority of the infections which are called surgical are due to this particular organism including boils carbuncles acute and chronic osteomyelitis and most infections in operative and accidental wounds. Although the administration of these drugs has undoubtedly aided in effecting the localization of these infections and has probably reduced fatality rates as a result the fact remains that the usefulness of sulfonamides in these lesions falls far short of what could be hoped for the ideal chemotherapeutic agent, consequently, the development and use of penicillin is of great significance in the field of surgical infections.

**Penicillin**—Unlike the sulfonamides penicillin is not inhibited by the products of tissue breakdown and it is highly active against staphylococci when it can be brought into contact with them. Penicillin was actually discovered by Alexander Fleming<sup>5</sup> in 1929 when he observed that accidental contamination of cultures of *Staph aureus* with the mold *Penicillium notatum* resulted in destruction of the staphylococci. He assigned the name penicillin to the secretion of this mold which contained the active antibacterial agent. Being impressed by the lack of toxicity of penicillin against

animals and against leukocytes in vitro he speculated on the possible usefulness of penicillin in the treatment of infections. The spirit of nihilism in respect to the possibilities of chemotherapy was so strong at that time that his work lay dormant for more than ten years—in fact until after the wave of enthusiasm for sulfonamide therapy had passed its peak. The demonstrable usefulness of the sulfonamides eventually dispelled this attitude of nihilism and with the war was added impetus Fleming's work was finally followed up by a group of investigators at Oxford University in a series of studies commencing in 1940. These workers (Florey, Chain, Abraham and others<sup>7, 8</sup>) succeeded in producing enough of the active agent to permit treatment of experimental infections in animals and they found that Fleming's intuition of a possible therapeutic usefulness for penicillin was actually capable of realization. After they had obtained encouraging therapeutic results in the treatment of staphylococcus infections in man it became a matter of great war time urgency to widen the scope of investigations on penicillin and to solve the problem of large-scale quantity production of this drug. Success in both avenues of work was rapidly achieved both in England and in the United States. By the spring of 1944 the scope of usefulness of penicillin in clinical infections had been extended well beyond the field of staphylococcal infections alone and the quantities of penicillin being produced were sufficient not only to meet the needs of the armed forces of Great Britain and the United States but also to permit extensive clinical investigations of infections in civil life as well.

Modern chemotherapy then has been developed around the utilization of these two types of agents namely sulfonamides and penicillin. Both types of drugs possess the characteristics which are essential in the treatment of established infections in the body: both are of a sufficiently low order of toxicity to be of practical value in the treatment of infections in man and both possess the property of being active in the test tube and retain this activity against bacteria in surgical infections when they are present as constituents of the circulating blood and tissue fluids. In this respect the sulfonamides

and penicillin are radically different from most of the chemical agents which are toxic to bacteria including the so-called antiseptics. In thinking of these drugs it is of the greatest importance at all times to keep in mind this fundamental distinction:

### THE BASIS OF CHEMOTHERAPY

In the action of a chemotherapeutic agent in the body there are involved three main sets of variables. The bacteria act on the host; this is the infection. The drug acts on the bacteria by definition. The drug usually produces some effect on the host; this constitutes the third side of a triangle of chemotherapy. There are other additional actions which are included within the scope of this triangle. The host responds to the presence of bacteria through the operation

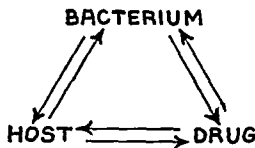


Fig. 9—The triangle of chemotherapy

#### BACTERIA → HOST

of the mechanisms of immunity. The host reacts to the drug and succeeds to a greater or lesser extent in inactivating or neutralizing the activity of the drug. Finally, the bacteria may also act on the drug and modify its chemical properties and its activity. This triangle of chemotherapy comprising a highly complex series of reactions is illustrated in Fig. 9. Some of these reactions will now be discussed in detail.

Bacteria produce deleterious effects on the host in three principal ways, each one of which is so closely related to the others that none may be considered as an entirely separate or distinct effect.

**Invasion of the Host**—First bacteria which are truly pathogenic must possess the ability to multiply in the tissue fluids of the host, utilizing the available nutrient constituents of the host fluids in their metabolism and to a varying extent modifying

the host constituents to suit their own metabolic requirements. Some types of bacteria are more capable than others of carrying out such processes for example the clostridia through the activity of their metabolic products are able to maintain the reduced level of oxidation reduction potential which they require in order to maintain their growth activity. However in order to produce these metabolic products which are in effect toxins it is essential that the organisms continue to multiply. When the hemolytic streptococcus produces a rapidly spreading infection in the body as seen in erysipelas or cellulitis the organisms multiply at a prodigious rate with an estimated generation time of less than thirty minutes. Through such geometric progression there occurs an enormous increase in the total number of infecting bacteria within a period of twenty four or forty eight hours. When the organisms multiply as rapidly as this time does not permit the development of suitable barriers against the active spread of the infection. Bacteria make their way into circulating fluids such as blood and lymph and are carried widely throughout the body producing bacteremia. The hemolytic streptococcus is undoubtedly the organism with the greatest predilection for producing bacteremia. *Staph aureus* multiplies at an equal rate but it tends to evoke a more complete local reaction at the site of the infection. An inflammatory barrier in the tissues around the site of infection is created rather early and the likelihood of widespread dissemination resulting from the infection is therefore not as great as is the case with the hemolytic streptococcus. It is in meeting the problem of invasive infection of these types that the sulfonamides and penicillin produce their most dramatic effects.

**Toxemia in Infection**—Bacteria not only invade the tissues of the host but also tend to elaborate toxins which produce injury to the host in a variety of ways. As has already been mentioned certain of these toxins are to be considered metabolic products of the organisms which are essential to them in maintaining proper conditions for their further multiplication and adaptation to the host. These toxins are of two main varieties.

**Exotoxins**—First are the so-called exotoxins which are filtrable non protein products of bacterial growth of which the erythrogenic toxin of the hemolytic streptococcus is a good example. Diphtheria toxin and the toxin of *C tetani* may also be cited. The exact mechanisms by which these toxins produce deleterious effects on the host are not at all understood. This aspect of infection constitutes a very important field of investigation which has as yet hardly been touched. The organisms produce these toxins only so long as they continue to multiply. Once the toxin has been formed it may be neutralized by the presence in the host of the appropriate anti toxin. Chemotherapeutic agents will not neutralize toxins of these types but by suppressing the ability of the organisms to multiply the further production of such toxins is indirectly reduced by the chemotherapeutic agents.

**Endotoxins**—The other types of toxin are the so called endotoxins. These substances are actually protein fractions composing part of the structure of the bacterial cell. As bacteria die out or are destroyed in the body these cell fractions become liberated into the medium and are then absorbed into the systems of the host. Some of them are highly lethal in their effects but here again the exact nature of their poisoning actions is not at all understood. Among infections in the general field of surgery a good example of such toxemia is peritonitis due to bacteria commonly found in the intestine. The colon bacillus is not a highly invasive organism in the sense that the streptococcus and staphylococcus are invasive. However the colon bacillus shares with other members of the family of colon typhoid dysentery bacilli the presence in its structure of highly toxic protein fractions which play a major role in the pathogenesis of peritonitis. Neutralization of these endotoxins by antitoxins is far less readily carried out than is neutralization of exotoxins. Here again however the ability of chemotherapeutic agents to suppress the growth activity of endotoxin producing organisms within the body tends to limit the amount of toxins produced and this results in marked benefit to the patient. There is some evidence that sulfonamides may play a part



in neutralizing the actions of certain endotoxins but this work needs further confirmation

**Local Destruction of Tissue in Infection**—Not only do bacteria invade the body and produce toxemia of the varieties described but their presence in the body tissues and the local reaction of those tissues to their presence tend to lead to varying degrees of damage to the architecture of the tissues. It is this element in bacterial infection which is of particular importance in most surgical infections for the characteristic which most clearly separates surgical infections from other types is the production of irreversible damage to the architecture of the tissues necessitating the replacement of normal tissue with scar tissue in the healing process. Surgical procedures must be used to aid in the removal of products of irreversible damage to the tissue and to facilitate completion of the healing of the wound which results. Destruction of tissue due to infection occurs by way of two mechanisms first through the locally destructive action of proteolytic enzymes which are formed by the organisms particularly by the staphylococcus and by certain of the clostridia and second by interference with the blood supply within the infected area. Some organisms produce toxins which act locally to cause thrombosis in capillaries and in blood vessels of even larger size. Operation of this mechanism may limit the dissemination of the infection but does so at the cost of local reduction in the blood supply and subsequent death of tissue in the infected area; moreover the edema which occurs at the site of infection produces local tension which may cause complete obliteration of afferent blood vessels and thereby lead to local anoxia and death of tissue. Chemotherapeutic agents must be administered in time to prevent the lesion from reaching the stage of impairing the blood supply in the infected part if they are to meet successfully this factor in infection. Once the blood supply has been cut off not only are conditions more favorable to the continuation of local bacterial growth but also the access of the drugs to the necrotic area will be limited to their ability to permeate dead tissue deprived of the capillaries through

which the drug normally gains access to the area of infection

Chemotherapeutic agents must primarily suppress the ability of bacteria to multiply in the intact tissue and in the body fluids of the host in so doing the toxemia and the local destructions of tissue by the bacteria will be checked. Let us now turn to another side of the triangle and consider the actions of chemotherapeutic agents on bacteria in the body.

#### DRUG → BACTERIA

Paul Ehrlich hoped that there would be found an agent with the properties signified by the term *therapia sterilisans magna*. With such an agent it was hoped that the administration of a single large dose would bring about the selective mass destruction of bacteria within the body and would result in immediate recovery of the patient from the state of disease produced by their presence. Experience has shown however that the chemotherapeutic agents which are of value in treating infection produce their selective action on bacteria—while sparing the host—by acting in a subtle way upon some stage of a metabolic process upon the continued operation of which the bacteria depend for their survival. Thus the action of sulfonamides and penicillin is in no sense a destructive one such as that produced by carboic acid or alcohol—agents which produce complete and irreversible damage to the structure of bacterial protoplasm. The true effect of the chemotherapeutic agent is to block completion of an enzyme reaction upon which the organism depends for its continued multiplication so that the organism ceases to proliferate when it comes into contact with an inhibitory concentration of the drug. This mechanism has come to be termed *bacteriostasis* in contradistinction to the bactericidal action of those antiseptics which actually destroy the bacteria on contact with them. It is the very subtlety of their action which probably permits the sulfonamides and penicillin to act on bacteria in the body. A chemical destruction of bacterial protoplasm in the body would undoubtedly be accompanied by destruction of host protein as well and the net usefulness of the agent would be lost thereby.

**Sulfonamides**—There is a good deal of evidence that the sulfonamides produce their effects on bacteria in the body because they bear a close chemical resemblance to *p*-aminobenzoic acid. The latter substance is presumably essential to bacteria and must either be produced by them or supplied to them in the medium. When a sufficient concentration of sulfonamide is present in the bacterial environment the molecules of sulfonamide enter the sphere of the chemical reactions of the cell where by masquerading as molecules of *p*-aminobenzoic acid without possessing the nutrient characteristics of this substance they wreck the continued operation of the particular enzyme system with which *p*-aminobenzoic acid is concerned. Of interest is the fact that the bacteriostatic action of the sulfonamides can be suppressed at any time by the addition of a high concentration of *p*-aminobenzoic acid to the medium. Sulfonamide can only block bacterial metabolism when the ratio *sulfonamide* : *p*-aminobenzoic acid is favorable to the sulfonamide. The foregoing concept of the mode of action of sulfonamides was first advanced by Woods,<sup>11</sup> and of several theories extant it is the one which appears to be most widely accepted by students of this subject. The concept of the competitive relationship between sulfonamides and *p*-aminobenzoic acid has contributed much to the development of an understanding of the nature of chemotherapeutic phenomena. Another point of considerable practical importance in connection with the mode of action of sulfonamides is the fact that peptone a common constituent of laboratory culture media and similar products of the degradation of animal protein which are present in dead tissue have an effect like that of *p*-aminobenzoic acid in suppressing the bacteriostatic action of sulfonamides.<sup>1</sup> It was at one time thought that this effect of peptones and other proteolytic products was due to their content of *p*-aminobenzoic acid but a good deal of doubt now prevails that such an explanation is adequate. Whatever may be the true explanation of this tendency of sulfonamide action to be suppressed in the presence of dead tissue it is a phenomenon of great practical importance in chemotherapy with sulfonamides. It explains why sulfonamide

therapy may be highly effective in the invasive stages of an infection before proteolytic degradation of tissue has commenced and so limits the spread of infection in architecturally intact tissues and yet fails to influence the persistence of bacteria in abscesses and areas of gangrenous or suppurating tissue.

**Penicillin**—Comparatively little is known of the exact nature of the action of penicillin presumably the action is one of even greater subtlety because the actual amount of penicillin necessary to induce bacteriostasis in the body fluids is less than 1/1000 as great as the concentration of sulfonamide required to produce an effect of similar magnitude.<sup>13</sup> It is suggested that the locus of penicillin action in the bacterial cell must be a mechanism which is more delicately balanced in relation to bacteria than it is in relation to host cells because penicillin produces no interference with the metabolism of host cells even in concentrations several thousand times that required to suppress the growth of bacteria in contact with those cells. Penicillin is not inhibited by *p*-aminobenzoic acid and peptone but it is destroyed by acids by contact with certain metallic ions by heat and by the enzyme 'penicillinase'. Penicillinase is secreted by some of the organisms such as the colon bacillus which are resistant to penicillin. For this reason the action of penicillin against susceptible gram positive organisms may be impeded if gram negative bacilli are also present in the lesion.

#### HOST → BACTERIA

The third reaction of major importance in the triangle of chemotherapy is the action of the host on bacteria. Since chemotherapeutic agents simply suppress the ability of bacteria to multiply and do not actually destroy them it is apparent that the final disappearance of living organisms from the infected host must be the result of the action of mechanisms such as phagocytosis and bacteriolysis by leukocytes and humoral agents normally present in the host. The presence of the chemotherapeutic agents tends greatly to increase the efficiency of phagocytosis as a clearing mechanism. Under conditions of invasive infection when bacteria are multiplying with unre-

strained vigor in the host the ingestion of bacteria by leukocytes may simply lead to the destruction of the leukocytes by the bacteria rather than the reverse. By preventing continuous proliferation of bacteria within leukocytes the bacteriostatic drug makes effective a mechanism which without the drug would fail to meet the desired objective. The usefulness of sulfonamides and penicillin is therefore greater in types of infections and in anatomical locations which are characterized by the development of an active phagocytic response. For example sulfonamides appear to be of specific usefulness in the treatment of infections in cavities lined by serous membranes in which inflammation tends to produce a particularly striking degree of phagocytic activity. This probably accounts for the clinical usefulness of sulfonamides in treating mixed infections of the peritoneal cavity in spite of the comparatively low susceptibility of intestinal organisms to the bacteriostatic action of sulfonamides. In some infections sulfonamide action may provide 90 per cent of the background of recovery, while the operation of immunity mechanisms provides only 10 per cent. This is apparently the case in pneumococcic pneumonia. However in other types of infections such as the form of peritonitis just mentioned the relative importance of the two agents may be reversed. Thus the action of chemotherapeutic agents in the body must at all times be viewed as only one of the elements in the process of recovery from the infection. It is of great importance to provide as far as possible conditions in which phagocytosis and other mechanisms of immunity are at optimal effectiveness. If the surgeon keeps this point in mind he will not depend on sulfonamide drugs to destroy bacteria in dead spaces and in the interstices of a foreign body within which leukocytes cannot function efficiently; he will make every effort to avoid leaving dead spaces and foreign bodies within wounds. Furthermore when he considers the marked inhibitory effects of the products of tissue breakdown on sulfonamide action he will not depend on sulfonamides to prevent infection of wounds in which the tissues have been so crushed by the primary injury or by surgical procedures

as to bring about the liberation of products of tissue degradation into the wounds. In handling wounds he will direct his efforts toward minimizing the sources for the liberation of such sulfonamide inhibiting products.<sup>14</sup>

#### HOST $\rightleftharpoons$ DRUG

The next set of chemotherapeutic phenomena comprises the interreactions of the host and the drug. These reactions are of two main types: first those concerned with the way in which the host absorbs, transports and excretes the drug, and second the toxic reactions of the host to the drug. The first set of phenomena constitutes the *pharmacology* of the drug and the second the *toxicology*. (For a detailed discussion of these topics see Spink's<sup>15</sup> monograph.) The pharmacology and toxicology of sulfonamides and penicillin will be briefly discussed in turn.

**Pharmacology of Sulfonamides**—It is a general characteristic of effective chemotherapeutic agents that they retain their essential chemical integrity after absorption into the body fluids. Obviously a drug which reacts rapidly with constituents of body fluids will probably in the process lose its ability to act upon bacteria. This constitutes an important reason for the generally unsatisfactory results of attempting to use chemically active antiseptics against bacteria in infected wounds.

The sulfonamides are absorbed fairly rapidly from the gastrointestinal tract. They tend with the same rapidity to be transported throughout the various tissues and organs of the body, and in general they become distributed with notable uniformity throughout the body water. Excretion through the kidneys commences promptly and proceeds at a rate which varies somewhat with different members of the sulfonamide series. Sulfathiazole is excreted with the greatest rapidity; sulfanilamide and sulfadiazine being removed at a somewhat less rapid rate. One of the possible avenues for improving the effectiveness of sulfonamides is through the development of compounds which while no more toxic are excreted less rapidly and therefore require smaller and less frequent doses. Sulfamerazine is a drug with chemotherapeutic properties quite sim-

ilar to those of sulfadiazine but one which apparently enjoys the property of slow excretion.<sup>16</sup> The sulfonamides appear in almost all of the body secretions including saliva, tears, sweat and wound exudates. The concentrations of various sulfonamides in the cerebrospinal fluid offer a rough index of the efficiency of their transport. Sulfathiazole appears in spinal fluid in a concentration only about 30 to 40 per cent of that existing in the circulating blood whereas the corresponding factor for sulfanilamide and sulfadiazine is in the range of 80 to 90 per cent. For this reason there is some theoretical advantage in using the latter drugs in the treatment of meningitis. The rate of absorption of these sulfonamides from wound depots tends to parallel their solubility.<sup>16</sup> Since sulfanilamide is by far the most soluble member it tends to be most rapidly absorbed from wounds and from the peritoneal cavity. Sulfathiazole is absorbed with considerably less rapidity and sulfadiazine is so insoluble as to resist local absorption for many days. These considerations are of practical importance in the local use of the drugs in the prevention of infections in wounds and burns. It is desirable to balance the factor of drug concentration against the need for prolonged local action. Where local concentration is high as is the case with sulfanilamide the drug tends to be non persistent and may be all gone within forty eight hours. However when a less soluble drug such as sulfathiazole is used the concentration of the drug in the fluids bathing the wound may remain in the effective range for several days. On the other hand a drug which tends to persist within the wound for several days is likely to set up a local foreign body reaction which is undesirable and may contribute toward delay in wound repair.

The only significant chemical modification of the sulfonamides which occurs during their passage through the body is the acetylation of the drug which takes place in the liver. Once the drug becomes acetylated it loses its bacteriostatic activity. The proportion of the drug so neutralized differs with each member of the series but is not significantly high with any of the sulfonamides now in common use.

A pharmacologic consideration of major

importance is the tendency of some of these drugs particularly sulfathiazole and sulfadiazine to crystallize out in acid urine. The process of crystallization within the kidney parenchyma results in obstruction to the formation and excretion of urine and large calculi may be formed in the calices of the kidney. This tendency may be overcome by maintaining an adequate urinary output in excess of a liter a day and by the administration of sufficient alkali in the form of sodium bicarbonate to preserve the pH of the urine at neutrality or above. In practice it seems necessary to give approximately 20 Gm of sodium bicarbonate every four hours in order to achieve this objective. [The intravenous administration of 1000 cc of one sixth molar sodium lactate solution will usually alkalinize the urine for twenty four hours—Ed.] This particular deleterious effect of the sulfonamides is discussed in relation to pharmacology because of its association with the matter of excretion of the drugs. In the case of sulfadiazine it represents the most important unfavorable effect of the drug. It is not an important consideration in relation to sulfanilamide because the solubility of this drug (and of its acetylated derivative) is so high that there is no tendency for the formation of crystals in the urine.

**Toxicology of Sulfonamides**—The most important toxic effects of the sulfonamides are a result of the development of sensitization to one or several members of the group. A factor of time is required for the development of sensitization and serious reactions of this type will rarely occur unless treatment is continued for more than ten days. The reactions take the form (in progressive order of severity) of skin rashes, drug fever, hemolytic anemia, agranulocytosis and exfoliative dermatitis. Fortunately the order of frequency of these reactions reverses their order of severity. The severe reactions are likely to occur only when drug treatment is continued following the development of one of the milder manifestations of hypersensitivity. Therefore if patients receiving sulfonamides are watched carefully for the development of skin rash, fever and progressive anemia the development of the severe and fatal complications may usually be forestalled. Once an individual has been

sensitized to one of the sulfonamides he may or may not be sensitive to another member of the series but the sensitization tends to be maintained for long periods of time therefore sulfonamide therapy must be administered with great caution to individuals who at some previous time have demonstrated any manifestations of hypersensitivity. It is a matter of considerable interest that individuals will rarely show these toxic reactions to sulfonamides until after manifestations of active infection have subsided. It is not known whether this is merely related to the duration of therapy or whether there is some basic immunological reason for the lack of association between sulfonamide sensitivity and active invasive infection by bacteria against which the patient has not yet acquired an immunity.

**Pharmacology of Penicillin**—Penicillin is utilized more efficiently when given parenterally than when taken by mouth. Like the sulfonamides when injected intramuscularly or intravenously it is rapidly transported throughout the circulating body fluids and lymph but unlike the sulfonamides it does not appear in significant concentrations in saliva, sweat, tears and spinal fluid. Penicillin does not appear to pass readily across endothelial or serous membranes a fact which is surprising in view of its relatively low molecular weight. It is excreted with great rapidity by the kidneys and in the bile so that a given dose administered intravenously may disappear entirely from the circulating fluids within two to three hours. It is therefore customary in severe infections to give penicillin by continuous intravenous drip or intramuscularly at intervals not exceeding three hours in length. If penicillin is administered by mouth approximately five times the parenteral dosage is required to maintain comparable blood levels and intervals of three hours should be employed. It is likely that new vehicles for oral penicillin which will make oral therapy more efficient will soon be available. However care must be taken to give the drug according to a rational plan designed to maintain an adequate blood level. Subeffective doses are likely to cause the infecting organisms to become penicillin resistant. The failure of penicillin to appear in significant concentrations in spinal fluid and in loculated exudates offers a theoretical basis for employing

intrathecal injections of the drug in the treatment of meningitis and intrapleural injections in treating empyema. Once topical injection of penicillin has been performed the resulting concentration within the cavity tends to be maintained for many hours and single daily instillations are usually sufficient. As would be expected from its solubility and rapid absorption penicillin rapidly disappears after local application to wound surfaces. If penicillin is to be of practical usefulness as a local application to wounds prior to their closure some means must be found to retain it within the wound for a much longer period than is possible when aqueous solutions or powdered forms are used.

**Toxicology of Penicillin**—A remarkable characteristic of penicillin is its virtual freedom from toxic action in the body. The occasional reactions of fever and urticaria which have been reported are probably due to impurities in the commercially available products and are not due to penicillin itself. The basis for this statement is the fact that the frequency of these reactions has tended to diminish as products of greater purity have become available.

#### SUMMARY

The theoretical basis for the use of chemotherapeutic agents in the treatment of infections and the general characteristics of the drugs now available for such use have been reviewed in some detail. The essential characteristics of an effective chemotherapeutic agent may be summarized as follows: 1 The drug should be active *in vitro* against pathogenic bacteria and should retain this activity within the body. 2 The drug should have a low tendency to react directly with host proteins so that it will not be inhibited or inactivated by normal constituents of the body. 3 It should be bacteriostatic rather than bactericidal that is it should exercise a subtle interference with a vulnerable phase of bacterial metabolism rather than a powerful destructive effect on the bacterial protoplasm. 4 It should be readily absorbed from the site of administration and should be rapidly transported throughout the body so that it will be able to reach the actual site of infection in an active concentration. 5 It should not exercise an inhibitory effect on phagocytosis. 6 Its toxic

actions on tissue cells through direct contact should be minimal

It is also possible to assign certain general characteristics to bacterial lesions most likely to be susceptible to the action of chemotherapeutic agents such as sulfonamides and penicillin as follows

1 The lesion should be due to a continuation of parasitic bacterial activity. A chemotherapeutic agent should not be expected to possess curative value in lesions where the bacteria are present simply as saprophytes and where active invasive infection no longer exists

2 The bacteria must of course be susceptible to the chemotherapeutic agent employed

3 The blood supply within the infected area should be adequate to permit transport of the drug to the site of bacterial activity in effective concentration. A lesion which is isolated from free circulation of blood and lymph will not be responsive to chemotherapeutic agents administered systemically but may yield to local therapy with the agent

4 There should not be present in the lesion a neutralizing concentration of any substance which inhibits the particular agent employed. In the case of sulfonamides the most important inhibiting substances are found in products of tissue breakdown and necrosis. In the case of penicillin the most important inhibitory substance is the enzyme penicillinase a by-product of the growth of penicillin resistant bacteria such as the colon bacillus

5 There should exist conditions favorable to the effective operation of antibacterial mechanisms such as phagocytosis

In general infections will be most responsive to treatment administered early rather than late therefore it is incumbent on the surgeon to institute chemotherapeutic treatment as soon as an accurate diagnosis has been made. Specific treatment must be designed to meet the particular conditions which exist in each individual case. For this reason the discussion of chemotherapeutic management of the various types of infections will be presented in rather general terms. Sound application of chemotherapy cannot be made through a resort to rule of thumb but must be based upon a clear definition of the objective in each case and

upon a fundamental knowledge of the properties of the therapeutic agents which are available

#### PRACTICAL USE OF CHEMOTHERAPUTIC AGENTS

**Bacteriologic Basis for Selection of Drugs**—Prior to the introduction of penicillin the sulfonamides represented the only chemotherapeutic agents of practical usefulness in the treatment of infections. Now however a state of transition exists in which the increasing supply of penicillin is making it possible gradually to substitute this drug for sulfonamides in those conditions in which it is definitely superior. Since the sulfonamides are likely for some time to remain cheaper and more readily available than penicillin it will probably be desirable for the present to continue the sulfonamides in those conditions in which the drugs are of approximately equal value. For this reason the sulfonamides should be used in the treatment of most acute hemolytic streptococcus infections and in pneumococcal pneumonia with penicillin being reserved for those cases in which the patient fails to respond to a reasonable period of sulfonamide therapy. Among the sulfonamides *sulfadiazine* is the drug of choice under most conditions because of its broad range of effectiveness and its comparatively low toxicity. Sulfonamides are preferable to penicillin in the prevention and treatment of peritonitis due to intestinal bacteria such as the colon bacillus which is in itself highly resistant to penicillin. The latter drug may be used in selected cases in which persistence of active infection is clearly due to the presence of *Staph aureus* or a hemolytic streptococcus and in which sulfonamide therapy has been shown to be ineffective. Penicillin is clearly the drug of choice in the treatment of all infections which are due to *Staph aureus* including cellulitis, bacteremia, pneumonia, empyema, arthritis, and meningitis. It is also apparently of greater value than sulfonamides in the treatment of infections due to *Clostridium welchii* and other members of the gas gangrene group. If penicillin is available it should be used in preference to sulfonamides in the prevention of invasive infections in severe accidental wounds, compound

fractures and burns. The reason for this is that most of the severe infections likely to occur in such wounds are due to types of bacteria susceptible to penicillin chiefly staphylococci, streptococci and clostridia. It is therefore apparent that the sulfonamides are no longer of dominant importance in relation to surgical infections and that penicillin seems likely to enjoy far wider usefulness in surgical practice than the former drugs. (For a review of the current clinical experience with penicillin in surgical infections see the report by Lockwood, White and Murphy<sup>18</sup>) [For the use of penicillin in peritonitis see report of Faulex, Duggan, Stormont and Pfeiffer<sup>31</sup>—Ed.]

**Treatment of Invasive Infections.** Including Bacteremia.—Most acute surgical infections involve what might be called an invasive component. This may be manifested by the existence of positive blood cultures or may be manifested only by evidence of a process which is spreading progressively from its site of origin. For example a carbuncle on the back of the neck shows an invasive component during its early stages which consists in the area of spreading cellulitis peripheral to the central focus from which the lesion originates. The overwhelming majority of acute infections which display an invasive component are due to the hemolytic *Staph. aureus* and the hemolytic streptococcus. The problem of treatment of the invasive component is fundamentally the same regardless of the particular type of infection and the structures or organisms concerned. The objective should be to bring about as rapidly as possible suppression of active bacterial proliferation in the invaded tissue, blood stream or lymphatics. If the organism is a hemolytic streptococcus treatment with sulfadiazine using an initial dose of 2.0 to 4.0 Gm. followed by 1.0 to 1.5 Gm. every four hours will usually bring the invasive component under control. Sodium bicarbonate 2.0 Gm. every four hours should be given along with the sulfadiazine. If the organism is a staphylococcus or one of the anaerobes of the gas gangrene group penicillin is to be preferred when available. The dosage of penicillin should be approximately 150,000 to 200,000 units per day given either by continuous intravenous drip or by repeated in-

tramuscular injections every three hours. If penicillin is not available the above dose of sulfadiazine should be employed. In connection with the administration of the specific chemotherapeutic agents the management must include very careful clinical observation to detect any focus of localization at the earliest possible time. If the patient tends to show continuous improvement under treatment with the specific chemotherapeutic agent it is permissible in most cases to temporize with the treatment of the local focus. However if he fails to improve after two or three days of intensive therapy careful consideration should be given the question of surgical drainage or removal of the focus of infection. This course is particularly applicable in the treatment of suppurative meningitis secondary to middle-ear disease and of acute osteomyelitis with or without bacteremia. At one time it was necessary to stress employing surgical procedures on these patients at the earliest possible time but now that powerful chemotherapeutic agents are at hand it has become possible to await a time of election after the acute invasive infection has subsided before proceeding with surgical intervention. This tends to minimize the extent of surgical intervention and avoids the superimposition of tissue trauma at the particular period when much depends upon the unimpeded operation of immunity mechanisms at the site of inflammation.

Along with the administration of chemotherapeutic agents it is very important to administer blood and plasma for the treatment of anemia and shock, oxygen for correction of cyanosis and intravenous or oral fluids for maintenance of proper hydration. Since the patient with high fever tends rapidly to exhaust his reserves of protein it is necessary to administer a diet high in protein and carbohydrates resorting if necessary to parenteral administration of plasma and protein hydrolysates. The local treatment of the focus of dissemination should include complete immobilization (with application of splints if the focus is in an extremity) and elevation. Immobilization encourages the establishment of a protective inflammatory barrier at the periphery of the focus and elevation helps to maintain circulation of the inflamed part by reducing

edema. If the focus is in the face the patient should be kept in a semi erect position unless he is in shock and talking and chewing should be forbidden in order to minimize movements of facial muscles. In a majority of cases a thorough application of these measures will bring the invasive component of the infection under control the patient's temperature and pulse will come down and a sense of well being will replace the preexisting state of anxiety of both patient and physician. A subsidence in the signs of acute inflammation within the focus itself may also occur. The surgeon is then confronted with the problem of how to deal most effectively with the local focus. If treatment has been begun sufficiently early in the course of the disease to prevent the development of abscess formation at the local site it is likely that continuation of chemotherapy will result in the patient's complete recovery without surgical intervention. However in the majority of cases some degree of irreversible damage within soft tissue or bone will have occurred. The presence of an abscess may be reflected by clinical evidence of swelling and fluctuation by persistence of marked pitting edema in the skin overlying the inflamed region and by local pain and tenderness. Under such conditions the surgeon should not hesitate to carry out surgical drainage. The operative procedure should be adequate to permit removal of all of the pus and necrotic tissue which may have formed. Subsequent local treatment of the wound will depend upon the type and locality of the lesion this subject will be discussed in connection with local therapy of infected wounds. Each of the general types of infections to be discussed subsequently may involve at the outset the management of an invasive component as described above. However regardless of whether the infection is in a serous cavity in soft tissue or in bone the fundamental management will be along the lines outlined in the foregoing paragraphs.

**Infections of Serous Cavities—Empyema**—Chemotherapeutic agents may be employed in *prevention* of empyema as well as in its *treatment*. The use of sulfonamide drugs in the treatment of pneumococcal pneumonia has greatly reduced the incidence of empyema as a complication of this dis-

ease. However empyema may occur in spite of sulfonamide therapy but the infection in the pleura is usually of a comparatively low grade character and is associated with the development of a very thick inflammatory capsule with varying amounts of fibrin in the exudate. Another serious form of empyema is that occurring after pneumonectomy and lobectomy. There is evidence that postoperative infections of the pleural cavity of this type may be prevented by the administration of penicillin to patients undergoing such operations. Administration of the drug should be commenced five to seven days before operation in dosage of 100 000 to 150 000 units per day and should be continued for seven to ten days after operation. This appears to be a particularly striking example of the use of a chemotherapeutic agent in the prevention of postoperative infection. The treatment of empyema has become somewhat modified through the availability of effective chemotherapeutic agents. It was formerly advisable to carry out closed drainage at the earliest possible time followed by open drainage with rib resection if the former procedure was ineffective. However empyema developing in a patient under treatment with chemotherapeutic agents is a less acute problem and it now seems desirable to employ repeated daily aspirations of exudate followed by injections of a chemotherapeutic agent into the cavity. Penicillin appears to be of greater usefulness than the sulfonamides in connection with such local use. Apparently the sulfonamides tend to be inhibited by the pus itself whereas penicillin is not, and the latter drug is effective against most of the pathogenic bacteria commonly found in empyema. When conservative treatment of this type fails to result in sterilization of the cavity and in progressive diminution in its size it will be necessary to employ open drainage rib resection and possibly decortication of the lung namely excision of the inflammatory wall so that the lung can re-expand and fill the cavity. However it may be desirable to postpone this procedure for several weeks while awaiting improvement from conservative treatment.

**Suppurative Arthritis**—The treatment of suppurative arthritis is essentially similar to that outlined for empyema. It is important



to maintain immobilization of the joint during the period of acute infection but active movement should be resumed as soon as possible after subsidence of the active process. Treatment should combine the use of systemic chemotherapy with aspiration and local introduction of penicillin as indicated. Here again the performance of radical drainage may be postponed and in the majority of cases may be avoided altogether.

**Peritonitis**—Chemotherapeutic agents may be employed in several ways in the prevention of peritonitis. In preventing peritonitis as a complication of operative procedures on the gastrointestinal tract the primary requirement of course is that the operation shall be technically satisfactory as regards maintenance of blood supply of the bowel at the site of anastomosis. No chemotherapeutic agent can succeed in preventing postoperative complications from massive necrosis of bowel or leakage at the suture line. Furthermore the surgeon must necessarily prevent the development of distention of the bowel proximal to the anastomosis by effecting adequate preoperative decompression. The role of chemotherapeutic agents is to prevent proliferation on the peritoneal surfaces of bacteria which have inevitably gained access to these surfaces during the course of the operation. Sulfonamides may be employed in three ways in prevention of peritonitis of this type. First the patient may be given preoperative doses over a period of six to seven days of a sulfonamide such as succinyl sulfathiazole which is retained within the gastrointestinal tract. This will bring about marked diminution in numbers or even complete disappearance from the feces of coliform bacteria and clostridia.<sup>19</sup> The numbers of intestinal streptococci are not affected by this treatment. The dosage of succinyl sulfathiazole is 0.25 Gm. per kilogram of body weight per day, divided into six doses administered at four hour intervals. This should be continued for five to seven days after operation. The purpose of sulfonamide therapy of this type is to minimize the number of pathogenic bacteria likely to gain access to the peritoneal surfaces during and following the operation. The second method of employing sulfonamides in preventing postoperative peritonitis involves the adminis-

tration of sulfadiazine systemically to the patient for forty eight hours before operation and for five to seven days after operation. Here the objective is to provide bacteriostatic concentrations of sulfonamide within the structures of the bowel wall and within the peritoneum as well as within the fluid bathing the peritoneal surface. Although sulfadiazine is not noticeably bacteriostatic in tissue concentrations against colon bacilli and intestinal streptococci it apparently exercises some restraining effect on their ability to multiply and will be particularly effective in preventing growth of hemolytic streptococci and staphylococci should they be present in small numbers. Therefore sulfadiazine administered systemically fulfills an objective not met by succinyl sulfathiazole the effect of which is limited to the bowel lumen. Hence it is quite reasonable to employ these two types of prophylactic treatment concurrently in the same case. A third method of employing sulfonamides in preventing postoperative peritonitis is to introduce a sulfonamide in powdered form into the peritoneal cavity in the region of the suture line at the conclusion of the operation. Although many surgeons are quite enthusiastic about this method of using sulfonamides it seems probable that its effectiveness is due largely to the circulation of the absorbed drug in local tissue fluids and the amount and rate of such absorption is harder to control with local implantation than if the drug is administered by mouth or intravenously. Furthermore there is evidence that drugs implanted locally in powdered form tend to cause local foreign body reactions and adhesions unless used in very small amounts and carefully distributed and if a rapidly absorbed drug such as sulfanilamide is used the high concentration of drug in the portal circulation may injure the liver. Regardless of the sulfonamide chosen the total amount placed in the peritoneal cavity should not exceed 5.0 Gm. The use of the drug locally is not essential if sulfonamide is given systemically in controlled doses.

Peritonitis is also of importance as a complication of acute appendicitis and other acute infections of portions of the gastrointestinal tract. Administration of the drug cannot commence until the infection has

proceeded to a point where a diagnosis can be made but if there is evidence that the infection of the peritoneum has not been dealt with adequately by the operation alone or if evidence of early peritonitis exists sulfadiazine in doses of 40 to 60 Gm per day should be given during the immediate postoperative period. The drug may be given intravenously until it is possible for the patient to take it by mouth. Here again it is possible to use local implantation of powdered sulfonamide at the site of infection but for the reasons outlined in the foregoing paragraph it seems doubtful that local use alone should be depended upon. Furthermore this route of administration may actually be unnecessary if proper systemic treatment is carried out.

The treatment of established peritonitis should include the administration of sulfonamides. The principal objective here is to suppress the growth activity of bacteria on and beneath the peritoneal surfaces in the hope of minimizing the amount of toxic products of bacteria which the patient will absorb and in the hope of promoting the formation of localized abscesses which either will drain spontaneously or will be subjected to surgical drainage. In view of the consistently low mortality rates which have been reported from appendiceal peritonitis since sulfonamides have been introduced it seems probable that this treatment is of definite value if used as an adjunct to proper surgical management. Certainly the beneficial results appear to have heavily outweighed the occasional toxic reactions which have resulted from administration of sulfonamides to these patients.

The usefulness of penicillin in connection with peritonitis remains somewhat uncertain. In cases where persistence of active infection and toxemia is clearly due to the presence of gram positive organisms the administration of penicillin may aid in the final recovery of the patient. However if penicillin is not to be wasted in the treatment of such cases they should be carefully selected on the basis of clinical course and bacteriological signs.

It must be emphasized again that chemotherapy in peritonitis is nothing but an adjunct to surgical management and may never be employed as a substitute for early

operation, meticulous technique and careful preoperative and postoperative correction of physiological abnormalities.

*Tenosynovitis*—Acute infection of the tendon sheaths presents a dull problem. In the first place this is a potentially invasive infection which if neglected may spread widely throughout the anatomical course of the structure and lead to disseminated sepsis. Also it tends to result in early destruction of the tendons which are of major functional importance. The invasive features of acute tenosynovitis can probably be dealt with adequately by carrying out the regimen outlined in the foregoing section on invasive infections. In this particular type of infection however it is usually desirable to resort to surgical drainage of the sheath rather early because persistence of elevated fluid pressure within the sheath tends to disturb the delicate blood supply of the tendon. If the patient is responding to chemotherapeutic treatment it may be unnecessary to carry out as radical and extensive an exposure of the sheath as has formerly been practiced but at least the sheath must be decompressed if spread of infection and destruction of tendon are to be minimized. Following operative drainage it may be desirable to employ topical application of powdered sulfonamide or penicillin. According to Florey and Williams the recovery of patients treated locally with penicillin occurs with strikingly greater rapidity than is seen in control cases in which treatment consists of surgery alone. Any method of treatment of this sort which serves to bring the active infection more rapidly under control should be of great assistance in effecting rapid restoration of function to the infected digits. Much of the disability frequently seen following these infections is probably due to the prolonged period of suppuration which often follows surgical drainage.

*Cellulitis—Hemolytic Streptococcus Infections*—The effectiveness of the sulfonamides is nowhere demonstrated more clearly than in the marked reduction in the frequency and severity of hemolytic streptococcal cellulitis which has occurred during the past few years. These infections which characteristically follow trivial wounds and in the untreated form display a very ful-

minating course ordinarily respond very promptly to the regimen just outlined for acute invasive infections. If treatment is commenced early the development of acute suppurative lymphadenitis may be aborted though in some cases the lymph nodes draining the infected area will become abscessed and will require surgical drainage.

**Staphylococcus Aureus Infections**—Chemotherapeutic treatment of acute staphylococcal infections of soft tissues including boils, carbuncles and similar infections in operative wounds is of value chiefly in preventing the spread of infection from the site of origin and in minimizing the amount of tissue destruction. Penicillin is clearly the drug of choice for use in such cases and should be given in doses of 100 000 to 150 000 units per day depending upon the severity of the infection. Even penicillin will rarely succeed in preventing the development of some degree of tissue necrosis and suppuration. This necrotic tissue either must be left to drain spontaneously or preferably should be removed surgically. After operation the local use of sulfonamides in the infected wound is of doubtful value because the necrotic tissue inhibits the bacteriostatic action of the drug. Penicillin appears to offer much more promise as a local application to infected wounds of this type but its efficacy will be greatly increased if the amount of slough and necrotic tissue is minimal. A major need in surgical therapeutics which has not yet been met is for an agent which will rapidly and effectively cause the separation of slough from wounds of this sort thereby considerably hastening the healing. Such an agent would probably do more to shorten the healing time of infected wounds than any measure calculated only to attack the bacteria. This is a matter which deserves further careful research in the field of applied biological chemistry and physiology.

Recurrent furunculosis is a serious clinical problem which is encountered with considerable frequency. These recurring crops of boils may be confined to one area such as the back of the neck or the axilla or may appear widely distributed throughout the body. It is not clear yet whether a course of penicillin treatment will serve to prevent the development of succeeding

crops of furuncles but in serious cases such treatment will deserve a trial. Dosages of 50 000 to 100 000 units per day should be continued over a period of ten to fourteen days. Another method of special treatment which has shown encouraging results involves the use of staphylococcus toxoid. Since the dosage varies with the particular type of toxoid used no attempt will be made here to outline specific treatment with this agent. Price<sup>21</sup> has recently advocated prolonged scrubbing of the skin with ethyl alcohol (strength 70 per cent by weight) as a means of preventing recurrences of boils. This is of great assistance in cases where the recurrences are in a limited anatomical region such as the neck or axilla. Gentle scrubbing with alcohol should be continued for fifteen to twenty minutes and repeated daily for several days. Alcohol used in this way serves to reduce the number of pathogenic staphylococci in the skin and may remove them altogether.

**Gas Gangrene**—Chemotherapy of established gas gangrene is limited in its effectiveness as long as gangrenous tissue is present. Obviously neither sulfonamides nor penicillin will gain access to bacteria which are proliferating in gangrenous muscle and fascia to which the blood supply has been shut off. Therefore one should never consider that the administration of either sulfonamides or penicillin alone will constitute adequate treatment for an established infection in this category. Furthermore these chemotherapeutic agents will not serve to neutralize the lethal and necrotizing toxins elaborated by the clostridia and they are therefore not substitutes for a specific antitoxin. The principal basis for the use of chemotherapeutic agents in gas gangrene is to prevent the spread of these organisms and of the staphylococci and streptococci which frequently accompany them into healthy tissue peripheral to the gangrenous focus. In treatment of these cases primary emphasis should be assigned to large doses of antitoxin and to thorough surgical removal of all necrotic tissue with resort to amputation when necessary. Penicillin or sulfadiazine in this order of preference may then be administered as in any acute invasive infection. Local treatment of the wound following debridement or amputation

may consist in irrigation with penicillin but at present there is substantially greater evidence in favor of the use of zinc peroxide. This is a white insoluble powder which when prepared in suitable form and suspended in water will liberate oxygen over a period of many hours. It is applied to the wound on packing which has been saturated with a creamy aqueous suspension of the powder, the wet dressing then being sealed in with a thick layer of petrolatum gauze in order to prevent evaporation of the water and subsequent crusting of the dressing. In the presence of an active infection of this type these dressings should be changed daily so that the wound may be inspected for evidence of further spread of gangrene. Zinc peroxide dressings will be of value only in cases where the necrotic tissue has been completely excised. (For further details of this subject see the chapter by Meleney on the Relationship of Bacteriology to Surgery.)

**Other Anaerobic Infections.**—Soft tissue infections occurring in wounds adjacent to any portion of the gastrointestinal tract from mouth to anus may contain pathogenic anaerobes of various types, chiefly anaerobic streptococci, fusiform bacilli and bacteroides. Almost invariably many aerobic bacteria such as hemolytic streptococci, staphylococci or gram negative bacilli are present in association with these anaerobes. It is probable that the anaerobic bacteria depend for their pathogenicity upon a symbiotic relationship to these other organisms, a point which has been well emphasized by Meleney. These anaerobic organisms are as a rule comparatively resistant to the action of chemotherapeutic agents including both the sulfonamides and penicillin. However if wounds containing these organisms are subjected to careful surgical debridement and if penicillin or sulfadiazine is given in doses adequate for invasive infections it may be possible to break up the symbiotic relationship by eliminating gram positive cocci which are susceptible to chemotherapy and thereby to facilitate healing of the wound and recovery of the patient. The same principle may be applied in the treatment of various types of chronic progressive ulcers which are discussed by Meleney in another section of this volume.

**Osteomyelitis—Chronic Osteomyelitis.**—The treatment for the acute stage of hematogenous osteomyelitis has already been outlined in the section on treatment of acute invasive infections. Therefore here one is concerned chiefly with the management of the local bone focus. In meeting this problem penicillin has been of outstanding usefulness. In the first place penicillin administered during the acute phase of the disease is more effective than sulfonamides in achieving early subsidence of the evidences of acute infection. If penicillin treatment is continued after subsidence of fever and of signs of local inflammation at the infected site, the development of x-ray evidence of bone destruction may be considerably delayed. However because the bone destruction in osteomyelitis is due to early loss of the blood supply of the involved area of bone it is quite likely that breakdown of the bone will eventually show itself in the x-ray, subsequently if penicillin treatment is discontinued. A flare up of active infection may occur in this region. X-ray evidence on bone decalcification does not alone constitute a reason for surgical intervention. If other evidence of active infection appears it will often be necessary at some point during the convalescence of the patient to resort to surgical drainage of such areas of sequestration as may ultimately appear. At this time sequestra if present and chronically infected granulation tissue are removed. Administration of penicillin should be commenced two or three days before such an operation in order to protect the tissues against spread of infection consequent to the trauma of operation. On the basis of experience to date which is still admittedly limited it does not seem to be necessary to carry out the radical removal of healthy bone which is required in the classical Orr treatment. The reason for this is that if penicillin is continued for two or three weeks after operation all staphylococci or streptococci will usually disappear from the wound exudate and the wound will fill with uninfected healthy granulation tissue. In the absence of any acute infection it may even be possible to employ primary closure of these debrided wounds though experience is as yet inadequate to justify recommending such a course. However since

a chemotherapeutic agent is at hand which is capable of producing such profound bacteriological changes it is not unreasonable to hope that these preliminary impressions will receive confirmation through extended experience. If primary closure of these wounds is possible an enormous saving of time and disability will result.

**Infection in Compound Fractures**—The problem of treating infection in compound fractures is essentially similar to the treatment of chronic osteomyelitis secondary to a primary hematogenous infection but with two important differences particularly if the fracture was originally due to external violence. First fractures of this type are frequently comminuted and an important factor in persistence of the infection may be the existence of devitalized fragments of bone which serve as foreign bodies. In addition foreign bodies of other types including clothing and fragments of projectiles may be present. Second many of these infections are polymicrobial in origin and may contain gram negative organisms and varieties of gram positive bacteria which are resistant to penicillin. These differences between infections in bone which are secondary to trauma and those which are due to hematogenous infection necessitate some modification in therapeutic management from that outlined in the foregoing section. In the first place surgical intervention must be somewhat more radical in scope in order to make certain that all foreign bodies have been removed. In the second place the result of preoperative penicillin therapy may be less satisfactory in the presence of varieties of drug resistant bacteria. Lyons<sup>2</sup> observed that postoperative closure of these wounds can be carried out successfully when all of the bacteria present were susceptible to penicillin treatment but when penicillin resistant anaerobes and other bacteria were present it was necessary to carry out the orthodox Orr treatment until the latter types of organisms had disappeared. He observed also that penicillin therapy which was continued without the use of surgical cleansing of the infected tissue would frequently result in healing of draining sinuses but that in such cases a later recurrence of local infection was to be expected. In this respect the experience of

Lyons with military casualties has been similar to the experience of surgeons who have dealt primarily with civilian problems.

Although the immediate results of combined surgical and penicillin treatment in chronic infections in bone have been highly encouraging it must be pointed out that final evaluation of this treatment must be based upon several years of follow up study. Bone may harbor quiescent infection for many years and the rapid healing which occurs with penicillin treatment is not necessarily indicative of complete eradication of bacteria from the lesion. Present results are sufficiently favorable to warrant wide use of this method and it is reasonable to expect that results will be far superior to those obtained with previous methods of management. At the same time one must preserve a guarded prognosis in respect to the end results of this treatment.

#### SPECIAL PROBLEMS IN CHEMOTHERAPY

In several of the foregoing sections some references have been made to the local use of chemotherapeutic agents in treating infections usually as an adjunct to chemotherapy by systemic routes. Recommendation has been made for the local use of penicillin in the treatment of empyema, meningitis, suppurative arthritis and infections of soft parts and bone but always in conjunction with the employment of such surgical procedures as may be required to afford adequate drainage of the lesion and removal of whatever pus and slough may be present. Zinc peroxide has been recommended for topical use in treating wounds infected with anaerobic bacteria but again only after adequate surgical procedures have been performed. The problem of the local use of antibacterial agents is a very complicated one therefore it seems appropriate to consider in the following sections some of the special matters which are pertinent to the local use of drugs both in the treatment of established infections and in the prevention of infection in wounds.

**"Antiseptics" in the Treatment of Infected Wounds**—The phase of chemotherapy which has received principal attention from surgeons during the past century has related to the use of antiseptics in the treat-

ment of localized infections of soft tissues and bone. Ever since Lister's use of carbolic acid to reduce the number of bacteria in wounds a practice which ushered in the era of modern surgery much attention has been given to the development of drugs which when applied to wounds would destroy the bacteria and therefore presumably hasten both the disappearance of infection and the ultimate healing. Literally hundreds of chemical substances have been tried out to meet this end. During the last thirty years the antiseptics which have received particular attention included various mercurial agents—bichloride of mercury ammoniated mercury mercurochrome metaphen and merthiolate a number of dyes—acriflavine proflavine gentian violet and propamidine and hydrogen peroxide zinc peroxide Dakin's solution (sodium hypochlorite) zinc chloramide and iodine. None of these agents may be administered by mouth or parenterally with any prospect of influencing infection in a local area either they are too toxic or are not absorbed or they are inactivated as soon as they come in contact with the protein in blood plasma or tissue fluid. Such usefulness as any of them may possess is limited to situations where they may be used topically either applied directly to an open infected wound or perhaps injected into an infected serous cavity such as the pleura or a knee joint. In general the results from local wound therapy of this sort have been disappointing and for the following reasons:

1 The chemical agent reacts as promptly with the protein of the wound exudate as with the bacteria so that the antiseptic effect so clearly demonstrable *in vitro* is of little significance within the wound.

2 The chemical agent is toxic to leukocytes and therefore interferes with the local operation of natural mechanisms of defense against bacteria. It may be said categorically that the beneficial antiseptic action of any drug will be more than counterbalanced if the drug has a toxic action on leukocytes.

3 The drug has a toxic action on host tissue and therefore tends to add to the amount of necrotic material in the wound—material which provides the best medium for growth of bacteria. By the same process the drug delays wound healing and interferes with formation of granulation tissue

so that even if the number of bacteria in the wound is reduced the cost in delayed wound repair from using the drug is greater than is justified by the immediate results.

It cannot be denied that under certain special conditions infected wounds treated with one or the other of these antiseptics will appear to heal more rapidly than could have been expected had specific treatment not been used. However whenever this happens the dresser of the wound should ask himself the following questions:

1 Would the wound have done as well had some neutral material of similar physical consistency but of no specific antibacterial effect been used in similar fashion?

2 If the agent was genuinely effective and if its value could be substantiated in controlled studies could one be certain that its value was due to its antibacterial action or was it perhaps due to some other simultaneously operative function such as stimulation of leukocytic reactions acceleration in volume flow of lymph into the wound or hastening of the separation of slough?

During World War I there was great enthusiasm for the Carrel Dakin treatment of wounds which involved the continuous irrigation of wounds with hypochlorite solutions through small rubber tubes carefully placed in the wounds so as to permit the widest contact between the fresh solution and all of the ramifications of the wound. It still remains doubtful whether the good results of dakinization were due to the meticulous dressing technic required the dissolving action of the alkaline Dakin's fluid on slough the mechanical washing effect of the solution which tended to remove wound debris or the irritant action of the hypertonic fluid which evoked the outpouring of large quantities of healthy lymph and fresh leukocytes. Each of these explanations for the usefulness of the Carrel Dakin treatment has received support by different groups of investigators. Similarly the value of zinc peroxide may actually reside entirely in the high and prolonged concentrations of peroxide and oxygen which it provides to the wound but on the other hand its usefulness may be due in no small part to the abundant exudate which its application to a wound evokes or it may be due to the fact that the insoluble porous particles of zinc per

oxide are an excellent medium for adsorption of bacterial toxins in the wound

Therefore the surgeon must remember that the application of an antiseptic chemical to a wound sets in motion an exceedingly complex chain of phenomena that action against the bacteria is only one item in the sequence and that more often than not the net result is unfavorable rather than favorable to the rapid healing of the wound.

The local treatment of an infected wound is never simply a problem of destroying the bacteria on the wound. For one thing the bacteria which are responsible for the persistence of the lesion are not likely to be located only on the surface of the wound where they come into contact with a locally applied agent; they are beneath the surface of the wound beneath an intervening layer of fibrin or of devitalized tissue through which the antiseptic agent may not penetrate. Furthermore persistence of the infection may be due not so much to any vital parasitic quality of the bacteria themselves as to the presence of fundamental alterations in the local wound physiology which are detrimental to the healing process and provide a medium for saprophytic growth of bacteria. For example the problem of treating the infection in a deep burn is primarily the problem of effecting separation of the devitalized burned skin and only in part the direct attack on infecting bacteria.

In attempting to meet the problems of the infected wound it is easy to be misguided into focusing attention largely on the bacteria but progress toward improving therapy of such lesions can be met only through recognition of the true nature of the process and of the relative importance therein of tissue alteration on the one hand and infection on the other.

*Penicillin enjoys more promise in the local treatment of infected wounds than any of the agents hitherto employed because it is innocuous to tissue; it is not inhibited by pus and products of tissue degradation and it is absorbed from the surface of the lesion. It has been applied in the form of powder solution and ointment but the best technique for its local use has not yet been developed.*

**Prophylaxis Against Wound Infections**  
—The use of chemotherapeutic agents in

the prevention of infection in accidental wounds and burns has received major attention in civilian and military surgery during the past few years. It has seemed entirely reasonable to expect that the presence in wound fluids of bacteriostatic concentrations of chemotherapeutic agents would tend to prevent multiplication of contaminating bacteria within the wound and thus prevent the development of infection. The importance of infection in wounds of military casualties has given particular impetus to investigation of this subject.

There are two logical ways of employing chemotherapeutic agents in preventing wound infections. The first involves the systemic administration of a drug as a means of achieving its bacteriostatic concentration in the wound fluids and especially in the tissue immediately adjacent to the wound. The second route of administration involves local implantation of the drug into the wound. With both methods of administration it is obviously important to initiate treatment at the earliest possible moment after injury in order to obtain the bacteriostatic effect before opportunity for proliferation of contaminating bacteria has developed. With these objectives in mind the United States Army has provided soldiers and medical corpsmen with tablets of sulfadiazine to be taken internally immediately after injury is sustained; they are also supplied with a powdered sulfonamide usually sulfanilamide in sterile packages for local implantation beneath the emergency dressing. It is hoped that such treatment will cause each patient to arrive at the casualty clearing station or hospital in a non-infected condition and that surgical treatment may thereby be rendered more effective. Similarly there has been a growing practice among civilian surgeons to employ local and systemic chemotherapy in the prevention of infection in compound fractures and contaminated operative wounds such as those occurring with operations on the gastrointestinal tract. The evaluation of these methods of prophylaxis must be based upon two different criteria. First does chemotherapeutic prophylaxis reduce mortality by preventing fatal septic complications of wound infection? Second does it prevent local infection within the wound itself? The

evidence from both military and civilian quarters justifies an affirmative answer to the first question. However the answer to the second question can be expressed only with definite qualifications. Although many individuals remain enthusiastic concerning the effectiveness of sulfonamides in preventing wound infection there is a good deal of evidence that such success is obtained only under special conditions. In the opinion of the author all of the evidence tends to support the continuation of the practice of administering sulfadiazine or penicillin systemically to all individuals with major accidental wounds including compound fractures. This practice is justified on the basis of the ability of the sulfonamide to prevent fatal infection regardless of whether it may be limited in its ability to prevent infection as a complication in the healing of the local wound. Furthermore it would seem that the theoretical and practical considerations support the practice of applying sulfonamides locally as soon as possible after injury and for as long as the wound remains open. Since most war wounds are permitted to remain open for at least a week before any question of closure is permitted it is desirable to continue the present military procedure. However a study carried out in civilian hospitals on wounds which were for the most part subjected to early primary closure has failed to yield evidence of the value of sulfonamides in preventing local wound suppuration; in fact the incidence of infection in wounds of soft parts and compound fractures was actually higher when sulfonamides were used than it was in the control cases in which no drug was given. This study which was reported in a preliminary way by Meleney<sup>3</sup> has led to conclusions which are definitely at variance with the opinions of many civilian and military surgeons whose attitudes are based upon general clinical impressions rather than controlled observations.<sup>4</sup>

A certain amount of the confusion which has arisen is due to the fact that different investigators have been concerned in their study and practice with different types of wounds. Therefore in order to clarify the status of prophylactic chemotherapy in relation to contaminated accidental wounds these will be placed in four principal cate-

gories and the place of chemotherapy in relation to each particular type will be discussed. Since there will be general agreement that either sulfadiazine or penicillin should be administered systemically in all cases of severe wounds as a means of preventing fatal septic complications this discussion will be concerned largely with the local use of chemotherapeutic agents.<sup>5</sup>

*Fresh Contaminated Wounds Just After Injury*—These are the types of wounds with which the medical officer or hospital corpsman is principally concerned on the battle field and in the first aid station. They characterize also the problems confronting the ambulance surgeon and the medical attendant in the receiving ward of the civilian hospital. The wound is contaminated and is therefore likely to become infected. But infection is not the only problem; hemorrhage and shock may also be present and these considerations require primary attention. Fractures and penetrating wounds of the chest and abdomen present certain special problems. Another dominant consideration will always be to transport the patient to a suitable operating theater with the greatest possible speed. However the time interval between first aid treatment and definitive surgical treatment may vary from a few minutes to many hours or even days. The objective which demands the use of prophylactic chemotherapy is to prevent proliferation of bacteria on the wound surfaces during this interval. The effectiveness of topically applied sulfonamides will for a few hours not be impeded by the presence of proteolytic products of tissue break down in the wound. Since the wound is not closed no question of possible interference of the drug with wound repair arises. Therefore the situation calls for the local implantation of the form of sulfonamide which is most readily available. Sulfanilamide may be used in amounts up to 15 Gm. in an individual case; sulfathiazole which is only slightly below sulfanilamide in the order of choice may be used in amounts up to 10 Gm. In either case, the drug should be distributed as widely as possible throughout the wound area even though it is introduced only at one part of the wound. Sulfathiazole and sulfadiazine are limited in this respect by their comparative insolubility but they enjoy compensat-



ing advantages through somewhat longer persistence in the wound. The locally applied drug serves the purpose of supplementing the bacteriostatic action of the sulfadiazine or penicillin which may be administered by systemic routes. At the time of this writing experience with the local use of penicillin in such cases has been inadequate to provide a satisfactory basis for its evaluation. It is doubtful if it will be of much value for this purpose until some method is discovered of causing it to be retained within the wound for at least a few hours. When applied in the form of an aqueous solution its effect is exceedingly transient.

*Contaminated Wounds Which Have Been Debrided or Trimmed and Left Unstitched Possibly in Anticipation of Secondary Suture*—This category includes most of the wounds treated in front line military hospitals and also those wounds in civilian hospitals which have not been subjected to primary closure. Here the degree of wound contamination has been reduced to a minimum by removal of severely damaged tissue and careful removal of foreign bodies. It is pertinent in this connection to quote Sir David Wilkie to the effect that too vigorous scrubbing of a wound surface is "The joy of the housewife but the agony of the biologist." Usually the wound will be packed loosely with some non-adherent material such as petrolatum gauze and if the wound is of an extremity a plaster cast or pressure dressing will be applied. In a wound treated in this way there would seem to be a decided advantage from attempting to delay proliferation of bacteria beneath the dressing by the local implantation of a sulfonamide. Here again the local drug is employed as a supplement to a sulfonamide or penicillin administered by systemic routes. Since the wound is left open to granulate there is no major question of interference with wound repair by the topically applied drug and even the less soluble compounds such as sulfathiazole may safely be employed for this purpose. If wound debridement has been adequate the drug may be brought into contact with all portions of the wound. Even though reports of controlled investigation on wounds of this type are not yet available to establish the superiority of end results in wounds so treated yet when these

are compared with wounds not implanted with sulfonamides continuation of this practice is to be recommended. It can do no harm and it appears on rational grounds to be entirely justified.

*Wounds Which Have Been Debrided or Trimmed and Closed Primarily With or Without Tension*—A special set of problems regarding the local use of sulfonamides arises in connection with the wound which is to be subjected to primary closure. Since current military practice is strongly opposed to primary wound closure this is not a matter of major concern in war surgery except in connection with wounds of the scalp, abdomen and thorax in which primary closure is necessitated for protection of underlying structures. It is a problem which arises very commonly in civilian hospitals where primary closure of accidental wounds is now a common practice. Civilian wounds are associated with less destruction of tissue than military wounds and are usually treated surgically within one or two hours of the time of the accident. Furthermore unlike many military patients the civilian patient may be kept under continuous clinical observation by the surgeon so that the development of infection in the closed wound may be recognized more promptly than is possible in war wounded who are being transported to fixed hospitals in the rear. Several factors may tend to interfere with the ability of sulfonamides to prevent infections in closed wounds. In the first place it must be remembered that neither locally applied sulfonamides nor penicillin will destroy bacteria which are retained within the closed wound. The drugs may greatly retard their tendency to proliferate and when conditions in the wound are favorable they might check bacterial growth until clearance by phagocytes has been achieved. However local activity of the drug will not continue for more than a few days and the time must come when the bacteriostatic action ceases to operate. At this time bacteria which have not yet been destroyed by the leukocytes will be able to produce local infection. In the second place, the sulfonamides possess only a limited bacteriostatic effectiveness against the staphylococcus which is present in four fifths of infections of accidental wounds. Third there may be present considerable amounts of

tissue break down products which will be retained in the wound until they are absorbed and which during their presence will tend to inhibit the bacteriostatic action of sulfonamides. The amount of such inhibitors will vary directly with the amount of devitalized tissue left in the wound after debridement or produced by the constricting effect of sutures and ligatures. Experience has shown that the incidence of infection in wounds closed under tension is far higher than in wounds closed without tension.<sup>3</sup> The use of sulfonamides will not diminish the likelihood that infection will develop in wounds of the former category. Fourth, there is some evidence that the local implantation of the less soluble sulfonamide derivatives such as sulfathiazole and sulfadiazine interferes with the rate and quality of wound repair. This deleterious action of sulfonamides can be minimized by resorting to the use of sulfanilamide or by employing only small quantities of the more insoluble drugs. The drug must be well distributed on the wound surface and never applied in massive aggregations. The amount required to produce a light frosting of the surface should never be exceeded.

What has been said of the use of local sulfonamides in preventing infection in accidental wounds may be applied with perhaps greater effect to the prevention of infection in contaminated abdominal wounds associated with operations on the gastrointestinal tract. In an earlier paragraph skepticism was expressed concerning the need for local implantation of sulfonamides within the peritoneal cavity in such cases. However, there is mounting evidence that the local use of small quantities of sulfonamide in the abdominal wound itself will tend to reduce the likelihood of postoperative infection. This may be due to the fact that such wounds do not require closure under tension; they contain minimal quantities of devitalized tissue and the bacterial flora may be generally more susceptible to the action of sulfonamides than are the organisms introduced under conditions of accidental injury.

**Chemotherapy in Burns**—Sulfonamides and penicillin have been employed in a variety of ways to reduce the incidence of infection in burns. Here again the primary consideration is to prevent the development

of fatal sepsis; therefore it is most important to administer the chemotherapeutic agent by systemic routes. Sulfadiazine must be given with some caution to the burned patient because of the possible association of kidney damage but penicillin may be given without fear of toxic consequences. Chemotherapeutic agents administered systemically will have little effect on the proliferative activity of bacteria on the burn surfaces but will prevent them from invading the underlying tissue. The amount of surface infection will tend to vary directly with the amount of devitalized tissue and will thus be much greater in third degree burns than in superficial second degree burns. Infection of this type may not lead to fatal consequences and in a sense may be considered as a saprophytic type of infection. However, it may be a factor in toxemia and may interfere with the successful application of skin grafts. The question has naturally arisen therefore as to whether the local application of sulfonamides or penicillin to the surface of the burn will reduce the severity of such surface infection.<sup>7</sup> The study reported by Meloney failed to indicate that sulfonamides are of particular value when used in this way. Some discrimination is required in selecting the types of sulfonamide preparation to be used on the surface of the burn. If comparatively soluble sulfanilamide powder is used on a large burned area, the rapid absorption of the dissolved drug may result in toxic concentrations in the blood. The rate of absorption of sulfanilamide may be retarded by incorporating it in an oily base but very probably its effectiveness is largely nullified when such a barrier against absorption is provided. Sulfathiazole appears to be absorbed much less rapidly from the surface of the burn and has been employed without toxic effects by Gurd, Ackman, Gernie and Pritchard<sup>8</sup> in the form of an oil in water emulsion. Sulfadiazine dissolved in triethanolamine has been recommended by Pickrell<sup>9</sup> and although difficult to apply and incompatible with the use of the currently favored pressure dressings, this preparation has appeared to be quite effective in preventing infection of superficial burns.

The local use of sulfonamides in burns does not seem to merit the emphasis it has received in many quarters. The principal ob-

jectives in local burn management should be the early application of a protective pressure dressing and encouragement of the separation of slough at the earliest possible time so that skin grafts may be applied to a healthy base before opportunity for the development of serious surface infection has arisen. If the local employment of sulfonamides does not interfere with these main objectives there is no reason for not employing them as one element in the local therapy.

### CONCLUSION

One unfortunate consequence of the prevailing interest in the use of chemotherapeutic agents to prevent infection in wounds and burns has been the trend toward an erroneous direction of emphasis in wound management. Regardless of the particular type of wound involved it should constantly be remembered that the bacteria in the wound and the effect on these bacteria of the chemotherapeutic agent is only one of a great many factors which enter into the achievement of the end result. More important than the use of chemotherapeutic agents is the provision of conditions which will be optimal for the healing of the wound. The introduction of the sulfonamides and penicillin has not made possible the abandonment of any of the principles of surgical management which experience has shown to be indispensable in the achievement of satisfactory wound repair.

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## TETANUS

**Definition.**—Tetanus is a disease of man and certain lower animals characterized by local spasm or general convulsive contractions of the voluntary muscles due to the action of a poison produced by a specific bacterial agent, *Clostridium tetani*

**Historical.**—The dramatic manifestations of this disease and its high mortality very early attracted the attention of medical observers so that fairly accurate descriptions are found in the older writings particularly those of Hippocrates<sup>1</sup> and Aretaeus.<sup>2</sup> In the early history of man two factors relating to the incidence of this disease are of considerable importance namely the frequency of bodily injury and the close contact of man with domestic animals and the soil. It was not until 1800<sup>3</sup> that the infectious nature of tetanus was suspected. In 1859 Richardson<sup>4</sup> suggested transferring the disease from man to animals by inoculating animals with blood from patients who had died of the disease. Success was not attained however until 1884 when Carle and Rattone<sup>5</sup> produced the disease in animals by transferring a portion of a human wound infected with tetanus. In the same year Nicolaier<sup>6</sup> produced typical spasms by injecting garden soil into animals. He then observed a bacillus which he considered to be the cause of the disease. Two years later Rosenbach<sup>7</sup> described the characteristic spores and attempted to obtain the organism in pure culture. The latter was first accomplished by Kitasato<sup>8</sup> in 1889 when he heated to 80° C for forty five minutes a mixed culture of bacteria obtained from a patient with tetanus. He then demonstrated that the causative organism was an anaerobic spore forming bacillus. In the same year von Behring and Kitasato<sup>9</sup> established the toxic nature of the disease by inoculating with pure culture filtrates and producing antitoxin in animals. The discovery of the organism was followed by extensive research with regard to its cultural characteristics the production of its toxins and the mechanism of its pathogenicity.

**The Etiological Agent.**—The *C. tetani* is a gram-positive spore forming bacillus which is strictly anaerobic. The spores are terminal and round and are thus easily distinguishable from the sporulating anaerobic bacilli of the gas gangrene group. The organism grows only in a medium or in an environment with an oxidation-reduction potential ranging between 0 and 15. It grows best at 37° C in a medium having a pH of 7 to 7.6. Stab cultures in gelatin or agar produce a typical "inverted fir tree growth" while on blood agar plates the culture spreads as a thin film. It does not

ferment sugars or digest protein. Its various forms may be divided into a number of groups which differ in their agglutination reactions (3 main types and 4 other rarer types) but all these groups produce the same toxin. This has at least two fractions one being hemolytic and the other neurotoxic<sup>10</sup> possibly one fraction causes convulsion and the other death.<sup>11</sup>

The organisms are essentially saprophytic. They are frequently found in the feces of horses cattle and sheep but to a considerably less extent in the intestinal tract of man unless he has been fairly recently in close contact with domestic animals. A study of the fecal discharges of urban dwellers revealed an incidence of less than 5 per cent but a similar study of a group of farmers or of soldiers who had recently returned from World War I yielded an incidence of 30 to 35 per cent of these organisms.<sup>11, 12</sup>

Tetanus organisms in pure culture are practically harmless when injected into the normal tissues of susceptible animals but if the tissues are injured by mechanical or chemical means or by concurrent infection with other bacteria the tetanus bacilli multiply and produce toxin.

**Natural Infection.—Portal of Entry.**—The experimental observation just mentioned probably applies to the disease as it develops clinically in man and in animals because in almost every case there is some evidence of tissue injury or concomitant infection. The organism may enter the body through a gunshot or knife wound a compound fracture or any gangrenous or traumatized portion of the skin, including a bed sore. It may also enter through more trivial injuries, such as insect bites or stings bites of animals, blisters from burns or other irritants, extraction of teeth or even trivial scratches.

**Development of the Infection.**—When the organisms have been introduced and have found conditions favorable for their growth, they multiply readily in situ but usually do not invade the body. They probably do not multiply as rapidly as other organisms because even in well established infections it may be difficult to recover them from the lesion. Occasionally they have been found in regional lymph glands but not in the blood stream or in distant organs or tissues. They produce their disease in a manner similar to that of diphtheria bacilli by developing a powerful exotoxin which is absorbed and carried to the susceptible tissues, where it produces the characteristic symptoms.

**Period of Incubation.**—This varies remarkably and represents the time it takes

the organisms to grow and produce their toxin plus the time it takes for the toxin to attack the susceptible tissues. A few cases have been reported in which the symptoms appeared within twenty four hours of the injury. In other cases the period of incubation has been prolonged over a period of weeks and one case has been reported in which the characteristic features of the disease did not appear for two hundred and thirty nine days. The greatest number of cases develop in seven to fourteen days.

*Symptomatology*—There are apparently two characteristic groups of symptoms depending to some extent on the location of the portal of entry and the manner and speed with which the toxin is produced and absorbed. The first is called local or ascending and the second general or descending tetanus. In local tetanus there is stiffening or twitching of the muscles in the region of the wound which may be so mild that it is not recognized as a manifestation of tetanus. It may pass off spontaneously or may gradually increase in severity and range until it spreads upward involving the whole body.

In the descending type the symptoms begin first in the small muscles of the face with stiffening of the masseter muscles which may progress until it is impossible for the patient to open his mouth (lock jaw). The muscles of the face may pull back the corners of the mouth giving a grimace called the risus sardonicus of Aretaeus. The pharyngeal muscles may be involved making it difficult for the patient to swallow. The muscular spasm gradually spreads downward to involve the muscles of the neck, chest, back, abdomen and extremities. In both the ascending and descending type when there has been extensive stiffening of the muscles the patient exhibits a series of clonic or tonic contractions of the muscles which may start in small groups and gradually spread until the whole body is thrown into a violent convulsion. Such attacks are frequently started by trivial external stimuli, a mere touching of the body with the hand or with the bedclothes, a jar of the bed, a sudden increase of light in the room or even a loud noise. The convulsions may increase in frequency until they are almost continuous and then the inability of the

patient to relax the diaphragm or the external muscles of respiration prevents the intake of air and asphyxia supervenes. It is thought that the frequent and more or less continuous contraction of the muscles produces a large quantity of lactic acid and consequent acidosis which is incompatible with life but death is essentially due to suffocation. The contractions of the muscles of mastication may be extremely painful because of the pressure exerted on the teeth but the cramp of other muscles is usually not so distressing except for their psychological effect on a very clear mental state.

*Pathology*—When examinations are performed on man and animals after death due to tetanus no pathologic lesions can be found except in experimental animals to which tremendous doses of toxin have been given. There is apparently no death of the cells of the central nervous system which are rendered hyperactive by the toxin nor of the muscle cells which are found grossly to be in a contracted state. In human beings in whom the disease has been prolonged through a period of several days and to whom it has been difficult to give proper nourishment there is a wasting process in the various organs and tissues of the body but no specific pathologic changes can be demonstrated.

Abel and his co-workers<sup>13</sup> have shown that when a minimal lethal dose or a sublethal dose of toxin is injected by any route into experimental animals it is rapidly taken up and fixed both by the highly specific tissues and by the non responsive tissue of the body. In these cases although the animal dies no toxin can be found in the blood and lymph and no toxin can be detected as such in the tissues of the body. If more than one minimal lethal dose is injected the excess can soon all be found to be present in an unchanged state in the blood and lymph. Any toxin in the tissues is then due entirely to the toxin present in the contained blood and lymph and no greater concentration is found in the central nervous system in the nerves or in the muscle than is proportionately present in the other organs according to their blood supply.

*Treatment—Rationale of Treatment*—It will be seen that the rational treatment of tetanus depends on an accurate knowl-

edge of the pathogenesis of the disease. This is not yet entirely clear in spite of the clinical and experimental investigations carried on over a long period of time. Until recent years the theory has been generally accepted that the toxin is produced locally in the region of the wound and that it reaches the central nervous system only by passing up the motor nerves to the anterior horn cells of the cord and thence spreading both up and down within the cord and backward to involve the sensory nerve cells. It was thought that whatever toxin was absorbed by the blood and lymph was distributed by the arterial circulation to the various muscles of the body and then in turn absorbed by the axis cylinders of their motor nerves. The absorption was said to be accomplished either by protoplasmic streaming within the axis cylinder by way of the perineural lymphatic ducts or up through the interfibrillar channels. The beginning in the face and jaw muscles of the symptoms of descending or general tetanus was explained by the fact that in these muscles the shortest route to the central nervous system was found. Local tetanus in the muscles near the portal of entry was explained by the absorption of the toxin by the motor nerves in these muscles with contraction occurring as soon as the toxin reached the motor nerve cells in the cord.<sup>14</sup>

However a number of investigators brought forth clinical and experimental evidence to cast doubt on this theory<sup>15</sup> and more recently Abel and his associates have brought strong evidence to light which seems to refute this conception. They have called attention to the fact that there is no such thing as protoplasmic streaming within the axis cylinder of the nerves and that the perineural lymphatic ducts pass upward to regional lymph glands and not to the spinal cord. Likewise there is no possibility for the toxin to pass up through the tissue spaces between the fibers in a nerve bundle. They believe that local tetanus is produced by direct action of the toxin on muscles in the neighborhood of the distributing focus and that all the rest of the toxin is rapidly taken up through the blood capillaries and lymphatic vessels into the blood stream and distributed throughout the body through the arteries. They believe

that there is no blood brain barrier' preventing the passage of the toxin into the susceptible central nervous system tissue and no barrier between the blood and other susceptible tissues. They do not offer any satisfactory explanations for the order in which symptoms appear in the descending form of the disease. These important studies have been confirmed and are being continued by Piror.<sup>16</sup>

**Prophylactic Treatment—OPERATIVE**—It is evident from the foregoing brief review of the pathogenesis of the disease that it is of the greatest importance to prevent the evolution of a lethal dose of the poison. When any condition exists or when any wound is produced which is likely to provide conditions favorable for the introduction and the growth of *C. tetani* treatment must be instituted which will make the establishment of this organism difficult if not impossible. The surgical procedure in the treatment of the wound requires the removal of all foreign bodies and devitalized tissue; no attempt should be made to close the wound. The margin of excision of course may have to be limited and a compromise may be necessary when the wound is in certain anatomical locations which make extensive excision of the part inadvisable as for example on the face.

**ANTISEPTICS**—Various antiseptics have been recommended for use after the excision of the wound. The most recent and probably the most important is zinc peroxide which not only inhibits the growth of all anaerobic organisms by producing a highly oxygenated environment but also has a detoxifying action on the toxin and yet does not injure tissue.<sup>16</sup> The use of penicillin in these wounds has been of such recent development that an adequate determination of its value has not yet been possible in a large series of cases but in vitro the growth of *C. tetani* is inhibited by penicillin.

**ACTIVE IMMUNIZATION**—In recent years encouraging efforts have been made to produce active immunity in such persons as soldiers who are likely to be subjected to wounds contaminated with tetanus organisms. It has been found that the injection of toxoid<sup>17</sup> or antoxin (toxin detoxified by formalin or alum precipitation) calls forth antitoxin in the body of the recipient. It

tle or no response is seen after the first injection but if the second is given three to six weeks later there is a sharp rise in the antitoxin content of the blood serum. This is maintained for a variable period of months and gradually disappears. If however a third injection of toxoid is made three to six weeks afterward there is sudden development of antitoxin which seems to be adequate to combat the majority of natural infections with the organism. Thus if a soldier is immunized by three injections of tetanus toxoid and later sustains an injury another dose or series of toxoid injections is considered to be more effective as a prophylactic than a dose of tetanus antitoxin. The use of toxoid practically eliminated tetanus from the French army early in the present war. That the American and British forces have been similarly protected has been amply demonstrated by the low incidence of tetanus in the casualties so far reported.

**SEROTHERAPY**—Sufficient tetanus antitoxin should be administered to neutralize promptly any toxin which may be produced. The usual prophylactic dose of tetanus antitoxin is 1500 USP units which represents enough antitoxin to neutralize 0.000 minimum lethal doses for a 150 pound man. The relative value of these prophylactic measures cannot be accurately estimated and one can be sure that no single measure will prevent tetanus in all cases. It was demonstrated beyond the shadow of a doubt by the experience of army surgeons in the first World War that the routine use of antitoxic serum was of tremendous value. The high incidence of tetanus in the early days of the war when antitoxin was not available as compared with the minimal occurrence of the disease when the antitoxin was given as a routine measure amply demonstrated its efficacy. When conditions were maintained which favored the development of tetanus such as in compound fractures or retention of foreign bodies which it was impossible to remove it was found necessary to repeat this prophylactic injection every week or ten days until it was certain that at the conditions no longer existed. When secondary operative procedures must be carried out for war wounds it is likewise necessary to repeat the prophylactic injection

because the traumatism of tissue in which tetanus spores may be lying quiescent might reactivate the organisms and reestablish conditions favorable for their multiplication and the elaboration of their toxin.

**Active Treatment**—**OPERATIVE**—When the initial symptoms of the disease have appeared the first requirement is to remove surgically the focus of infection or the toxin factory. This requires complete excision of the wound and removal of all foreign bodies and necrotic or grossly infected tissue. No attempt should be made to close the wound.

**ANTISEPTICS**—After the surgical procedure the wound area should be flooded with a creamy suspension of effective zinc peroxide. By effective zinc peroxide is meant the medicinal grade of that product which has been dry sterilized according to instructions and which when added to sterile distilled water to the amount of 5 Gm in 50 cc will settle as a soft curdy precipitate leaving the supernatant fluid clear and will cause the evolution of oxygen within the first hour with continued evolution during the next twenty four hours. It is important to make certain of the contact of this creamy suspension with every part of the wound. In many cases it is necessary to pack the wound gently with fine mesh gauze or absorbent cotton soaked in the zinc peroxide suspension so as to keep the surfaces of the wound apart. The dressing should then be covered over with water soaked cotton and then with vaselin gauze to prevent evaporation.

**CHEMOTHERAPY**—Penicillin should then be given systemically at the rate of 200,000 units daily either continuously by intravenous or intramuscular drip or every two hours by intramuscular injection.

**SEROTHERAPY**—Further treatment is directed toward the neutralization of the toxin which has been distributed throughout the body. Potent antitoxin in measured USP or international units may be introduced subcutaneously intramuscularly intravenously or intrathecally and should be given in large quantities within the first twenty four hours. Although many observers (Sterrington<sup>18</sup>, Nicoll<sup>19</sup> and others) advocate the intrathecal route Abel and others maintain that it offers no advantage be-

cause the antitoxin is rapidly absorbed in the blood stream from the spinal fluid and does not come in contact with the toxin already fixed within the central nervous system. There are no dependable statistics to prove whether or not the intrathecal injection is of value. During the last war Bruce<sup>9</sup> gave some statistics for the British army showing that the mortality had been reduced from 57.7 per cent in 1914 to 1915 when tetanus antitoxin was not available to 19 per cent in the last period of observation (1917). This improvement was due not only to the prophylactic use of serum but to the improved surgical technic. But in the last 100 cases in which presumably the surgical technic was the same the men who had received prophylactic serum showed a mortality of 17.7 per cent and those who had not been given prophylactic serum a mortality of 28.5 per cent. One would suppose that in the active treatment of tetanus with serum better figures for recovery would be found for the group receiving large doses of serum on the first day in which symptoms appeared but such is not the case. In like manner if intrathecal injections of serum were of any special value one would expect a lower incidence of mortality in those cases in which it was administered in that manner but again there are no convincing figures to prove this point. It must be remembered however that it is almost impossible to evaluate these measures properly because as a general rule the series cannot be comparable. The patients with the most severe cases would be likely to receive antitoxin in large quantities by every route possible as soon as symptoms appeared and they in turn might show a high mortality while those with mild cases for whom serum treatment was postponed and was given in relatively small doses might show a high incidence of recovery. With the present limitation of knowledge with regard to the mode of action and the impossibility of estimating the amount of toxin already elaborated in any given case it seems best to lay down the following rules for the administration of antitoxin.

As soon as the diagnosis is made 20 000 USP units should be given intravenously 10 000 units into the muscles of the neigh-

borhood of the wound if possible and 10 000 units intrathecally after the removal of an equal amount of cerebrospinal fluid. The intravenous and intramuscular doses should then be repeated every four hours and the intraspinal injection every twenty-four hours until the outcome has been definitely settled. Some advocate the administration of as much as 500 000 units in the first twenty-four hours subsequent amounts being determined by the response of the patient to the treatment.

*Symptoms.*—Measures must be taken to combat the distressing effects of the muscular contractions which recur often with increasing frequency during the progress of the disease. Attacks are often brought on by various forms of afferent stimuli which should be minimized. The patient should be kept in a darkened room removed from all avoidable noises. The bed should not be jarred and the patient should be handled gently. If the contractures become violent frequent or painful the patient should be kept under the influence of sedatives which also serve to minimize his apprehension. The milder forms of sedation with the barbituric acid derivatives may not be sufficient but sodium amytal is the best of these and may prove sufficient for the milder spasm. Morphine which has the deleterious effect of repressing respiration should not be used. By far the safest sedative is ether in which the patient may be kept continuously subdued for many hours but the dose should be limited to from 60 to 80 mg per kilo of body weight for larger doses may depress the respiration. Under its influence the muscles may completely lose their hypertonicity although this is not always possible. The return of spasm within the muscles even before the patient has shown evidence of coming out of the narcosis is an indication for its readministration. If spasticity of the respiratory muscles or action of the toxin on the center of respiration becomes manifest artificial respiration is necessary and can best be accomplished with the Drinker respirator.<sup>11</sup> When a prolonged narcotic is administered the danger of the development of pneumonia becomes great particularly when aeration of the lungs is limited by spasm of the respiratory muscles. Feeding the patient dur-



ing the period of prolonged narcosis must be handled with greatest care and elimination must be effected by rectal treatment. Improvement in the patient's condition is evidenced by an increase of the interval between the spasmodic seizures and a gradual relaxation of the contracture and hypertonicity of the muscles. The administration of narcotics can then be interrupted and gradually eliminated.

The high mortality of this disease after the development of symptoms should not lessen but should rather increase prompt and effective administration of all the aforementioned methods of treatment and these methods should be continued until the patient is completely out of danger or has succumbed. In many cases initial improvement has caused the surgeon to be unduly optimistic of the outcome or on the other hand the continuation of symptoms has led him to be unduly pessimistic. More careful study of the pathogenesis of the disease is essential before there can be hope for further lowering of the mortality rate.

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#### RABIES

##### (Hydrophobia Lyssa)

Rabies is an acute infectious disease of dogs, horses, cattle, squirrels and other lower animals due to a filtrable virus found in the saliva. It is transmitted by a bite and is invariably fatal in human beings. In Illinois in 1936 18 466 dog bites were reported with 10 deaths from rabies. Cornell says that only 30 per cent of human beings bitten by rabid dogs die of rabies. The neurotropic virus passes along the nerve axons, cylinders from the site of inoculation to the central nervous system. At autopsy the brain shows the presence of specific Negri inclusion bodies.

The incubation period is shorter when the distance from the bite to the brain is less, varying from two weeks to over a year but is usually forty to sixty days. In a typical human case there is a short period of restlessness, apprehension and malaise which is followed by the excitement stage in which there is a violent spasm of the muscles of swallowing and respiration. Attempts to swallow bring on an attack and the patient will refuse even water. A circumstance which caused the disease to be termed hydrophobia. Saliva drips from the mouth owing to the patient's inability to swallow. The final stage is characterized by paralysis.

The high mortality of rabies (100 per cent) makes the treatment of animal bites of great importance. If it is known with certainty what animal caused the injury and

if this animal shows no signs of rabies the wound should be scrupulously cleansed with soap and water debrided if necessary and if indicated closed. This treatment is permissible only if the animal can be kept under close observation for two to three weeks and examined by a competent veterinarian. If the animal has been bitten by another animal Rosenau believes it should be quarantined for six months. If the animal has rabies develops rabies shows suspicious symptoms or is unidentified the patient should be given 14 to 21 doses of antirabic vaccine. Public health authorities advise the cauterization of all parts of the wound including the skin edges with 'fuming' nitric acid in every case if the animal is rabid. Meticulous cleansing with soap and water is thought by some to be preferable to cauterization. Any person whose appar-

ently intact skin has been contaminated by the saliva of a rabid animal should receive the prophylactic injections. All animal bites should immediately be reported to local health and police officers.

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### III. ANTHRAX, FUNGUS INFECTIONS AND TULAREMIA

#### ANTHRAX

(*Malignant Pustule, Splenic Fever, Malignant Carbuncle, Pustule Maligne*)

**Definition.**—Anthrax is an acute infectious disease caused by the *Bacillus anthracis* and characterized by the rapid development of a carbuncle-like lesion associated with severe constitutional symptoms

**Etiology.**—The disease is largely one of herbivora, attacking cattle, hogs, sheep and goats. Zoologically, and geographically, it is one of the most widespread of all infectious diseases. Among humans it occurs most

the point of inoculation. At first the lesion may simulate an ordinary furuncular infection, but it rapidly becomes transformed into a bulla filled with blood and pus. The surrounding tissue is indurated and board-like, and the edema is pronounced. The bulla ruptures exposing a dark brown eschar situated on a markedly inflammatory base, about the borders of which are seen minute translucent vesicles. The neighboring lymph glands are enlarged and may suppurate.

The lesion may occur on the face or neck if the infection has been the result of using an infected shaving brush and on the shoulder, arm or hand if due to the handling of diseased hides or skins (Fig. 10). In some cases the attendant symptoms of headache, high temperature and delirium are marked, in others the temperature may be only slightly elevated and the constitutional symptoms mild. The course of the disease is short; the patient either dies as the result of septicemia or recovers as the result of proper treatment.

**Diagnosis.**—The finding of a brownish black eschar situated on an exposed surface of the body, surrounded and covered by small vesicles and placed in the center of an area of marked swelling in a person whose occupation exposes him to anthrax infection generally suffices to establish the diagnosis. Anthrax bacilli are usually found in the smears.

**Treatment.**—At one time early and radical excision of the lesion was advocated. Best results now are obtained by leaving the lesion alone. Incision, excision or injections of chemicals or serum into or around the lesion is definitely contraindicated.

In a recent report Herman Gold reviewed his results in the treatment of sixty patients. Antianthrax serum was administered to twenty-one of the patients, twenty of whom recovered. The one who died had received an inadequate amount of serum intravenously and had been given injections of serum around the lesion. The average total dose of serum was 875 cc. administered in most cases in two or three intravenous in-



Fig 10—Anthrax

frequently among those who handle hides, hairs, bristles, wool, horn and bone and among farm laborers, shepherds, butchers and veterinarians. Shortly after World War I a number of cases of anthrax occurred as a result of infection from cheap pony-hair shaving brushes. *Bacillus anthracis* was the first organism discovered to bear a specific relationship to an infectious disease. It occurs as a large, straight, rod-like bacillus from 4.5 to 10  $\mu$  long and from 1 to 3  $\mu$  wide. It may occur singly or in pairs in film preparations. Its ability to form spores makes it extremely resistant to chemical and physical agents. The disease gains entrance to the human host by direct inoculation of the skin, seldom by ingestion or inhalation.

**Symptoms.**—A few hours or a few days after infection an inflammatory papule, accompanied by severe itching, develops at

jections. The initial dose should be 200 to 500 cc repeated every twelve to twenty-four hours until the edema is checked. Control of the edema is the most reliable means of determining whether sufficient serum has been administered. In addition to serum intravenous injections of neoparsphenamine were given to six patients but this drug did not shorten the course of the disease or materially add to the chances of recovery. Sulfonamides were used in forty-two cases with excellent results in thirty-nine. Patients should be treated intensively with sulfapyridine and sulfathiazole but if they fail to respond after three days antirithrax serum should be used. Sulfathiazole is the drug of choice. Gold believes that the illness was definitely shortened in his cases by the use of sulfonamides and that the sulfonamides are a safe and reliable substitute for serum and should be given preference in the treatment of anthrax.

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### SPOROTRICHOSIS

**Definition.**—Sporotrichosis is an infectious disease caused by a specific fungus, the *Sporothrix schenckii*, and characterized by the development in the skin of indolent nodules and abscesses. The disease may be localized or systemic; cutaneous, subcutaneous, osseous and visceral lesions may be present simultaneously.

**Etiology.**—Farmers, gardeners and florists are especially affected and the disease occurs so frequently in rural districts that it suggests most strongly that the favorite habitat of the fungus is grasses, shrubs and other vegetable matter. More cases have been reported from France and from the Mississippi River basin than anywhere else. The sporothrix is strictly aerobic; it grows on ordinary media but especially well on those containing sugar.

**Diagnosis.**—The diagnosis of sporotrichosis is made by the cultivation of the organism on suitable media or by its inoculation into animals. It is difficult to isolate the organism from pus in suspected cases.

**Pathology.**—In sporotrichosis the pathologic picture is that of a chronic granuloma. The fungus can but rarely be demonstrated. All observers agree that three zones make up the granuloma: a peripheral zone where there is an intense inflammatory reaction of the connective tissue and the infiltrate is made up of plasma cells, lymphocytes and some connective tissue cells; a midzone in which are found numerous giant cells of the Langhans type and epithelial cells arranged in typical tubercle formation with a central zone in which are seen large numbers of pus cells lying in a fine or coarse connective tissue network.

**Symptoms.**—More than six clinical varieties of this disease have been described. The most important, however, are the localized lymphangitic and the multiple gummatous types. The disease is seldom recognized early. In fifty-one of 145 reported cases the disease had existed for four months before suitable treatment was instituted. Although it is usually characterized by the extreme indolence of its development and course and by an absence of fever and systemic symptoms, its onset may be abrupt with fever, symptoms of an acute septicemia and a rapid development of lesions.

The first or lymphangitic type is the one most commonly seen in this country. A wound on the finger, thumb, forearm or hand serves as the portal of entry for the sporothrix. The initial lesion may simulate a simple ulcer, a furuncular pustule or an abscess. In some cases it may have almost entirely disappeared by the time that the succeeding symptoms develop. From a week to a month after the appearance of the initial lesion a chain of nodular swellings develops which follows the course of the lymphatics. The nodules slowly enlarge, some remain as painless nodular swellings, some soften with the formation of cold abscesses while in others the skin over them breaks down and indolent gummatous ulcers result. The chief lymphatic vessel extending from the initial sore can generally be felt as a thickened cord-like structure.

A second type not often seen in this country but often seen in France is characterized by the development of numerous lesions distributed over the trunk and limbs. They begin as nodules the size of a pea and enlarge slowly to lesions the size of a walnut. They only occasionally break down to form syphilitic ulcers. Generally they soften and form cold abscesses.

In the cases that have occurred in this country the lesions have broken down to form three types of ulcers: a tuberculous ulcer which is fistulous in character with narrow irregular openings, scanty pus and a dirty granulating base that bleeds easily; a syphilitic ulcer in which the lesions are crateriform, clean cut with sharp edges and an ecthymatous ulcer in which the lesions are superficial, heavily crust covered and only moderately inflamed.

In addition to the skin the disease may attack the muscles, bones and mucous membranes, especially those in the larynx and pharynx. Sporotrichal gummas have been found beneath the periosteum and cases of tibial periostitis due to the sporothrix have been reported.

**Treatment**—Surgical treatment is not indicated in sporotrichosis. Incision into the lesions increases growth rather than promoting involution. Potassium iodide by mouth in fairly large doses is almost a specific. Sodium iodide administered intravenously has also been of service in clearing up the disease.

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### ACTINOMYCOSIS

**Definition**—Actinomycosis is a disease affecting man, cattle and swine and characterized by the development of granulomatous tumors. These tumors fistulize and from their discharge the characteristic velvety sulfur like granules may be obtained.

**Etiology**—Considerable confusion has been hedged about the origins of actinomycosis in man. The general assumption has been that the disease is conveyed to man in the following manner: A cow with lumpy jaw (actinomycosis) and a discharging sinus grazes at pasture, other cattle or human beings chew the grass upon which the actinomycetes were discharged and the disease is perpetuated. The present view and one that has gained adherents among both clinicians and bacteriologists is that actinomycetes frequently are harbored about the teeth and in the crypts of the tonsils and granted lodgment of the organism in a mucosal wound of the alimentary canal the disease process may be set in motion. Lord championed this view as long ago as 1910. The barrier to more general acceptance of the endogenous mode of origin of actinomycosis in man was that the cultural and morphologic characters of actinomycetes recovered from the oral cavity of patients with actinomycosis appeared to differ from the cultural and morphologic characters of the *Actinomyces bovis*. The latter organism was isolated from exudate by Harz in 1877 and its anaerobic character was established by Wolff and Israel in 1891. Emmons' obtained pure cultures of microaerophilic species of actinomycetes from carious teeth and from tonsillar crypts. Upon repeated subculture these actinomycetes and their hyphae behaved morphologically and culturally very much the same as did *Actinomyces bovis*. Emmons examined 100 pairs of tonsils removed by tonsillectomy and in forty seven found actinomycetes whose filaments exhibited the identical morphologic and staining reactions of *Actinomyces bovis*.

The clubbed ends of the twisted mycelial filaments together with their radial arrangement accounts for the fact that the actinomycetes colony is known as the ray fungus. The organism is gram positive.

**Pathology**—Lodgment of the ray fungus *Actinomyces bovis* in tissue brings about a granulomatous type of reaction in which the features of an acute as well as a chronic infection may be concurrently noted. Immediately about the organism a zone of cellular activity usually occurs in which are large masses of polymorphonuclear and mononuclear leukocytes and epithelioid cells.

and a rich network of young blood vessels. This reaction becomes manifest to the unaided eye as abscess formation with burrowing pus channels filled with purulent collections containing the yellow sulfur like granules of the actinomycetes colonies. The vascularity of this granulomatous process is always striking at operation. Hemorrhage from this tissue when curetted away may be alarming, lending the impression that a large blood vessel has been opened, yet slight gentle pressure with a gauze pack usually serves to arrest it. The yellow color of the exudate is due in large part to the presence of pseudanthrax cells rich in lipoids. The actinomycetes are non mobile but are carried into the surrounding tissues by macrophages.

Peripheral to this area of necrosis and liquefaction is observed a proliferation of dense connective tissue—an attempt to localize and stop the destructive process. The brawny induration observed clinically in cases of actinomycosis is afforded by this keloid like proliferation of connective tissue. Central softening and peripheral induration with the suggestion of remarkable vascularity as imparted by the color of the skin are the gross features of the actinomycotic process which is about to rupture through the skin. Spontaneous fistulization with discharge of yellowish exudate is not unusual. In man primary involvement of bone is infrequent and is usually observed as an extension from an adjacent process. In cattle involvement of the jaw bone is the most frequent initial lesion of true actinomycosis.

*Sites Where Actinomycosis May Occur*—There are essentially three regions in the body where actinomycosis commonly occurs viz (1) the head and neck (2) the thorax and (3) the abdomen. The usual portal of entry for cervicofacial actinomycosis is believed to be the mouth for thoracic actinomycosis aspirated or ingested organisms lodge in pulmonary tissue or penetrate the esophagus. The usual lodgment of organisms which give rise to abdominal actinomycosis is the ileocecal segment of the intestinal canal.

*The Spread of Actinomycosis*—When the disease is recognizable clinically the portal of entry ordinarily remains but a conjecture.

The proximity of the disease process to one of the commonly accepted sites of origin of the disease merely suggests it as the portal through which the infection invaded the adjacent structures. Actinomycosis exhibits an extraordinary ability to extend into healthy tissue leaving no trace of the disease at the site of entry. This is particularly true of abdominal actinomycosis. It is likely that isolated actinomycosis in a subphrenic abscess, the kidney, the urinary bladder, the female generative organs or the abdominal wall or a collection of actinomycotic exudate eroding the lower thoracic or lumbar spine commonly may have its origin in actinomycosis which initially found lodgment in the cecum.

Actinomycosis rarely becomes generalized in the sense in which a tumor metastasizes though instances apparently have occurred to indicate that distal spread by the blood stream does take place. Most of these cases concern the invasion of a pulmonary vein by an actinomycotic process in the lung, its entry into the left heart and its propagation as a thrombus into one of the cerebral vessels with lodgment in the brain. Jacoby (1928) reviewed a number of these instances. Cerebral actinomycotic abscesses are sometimes multiple. Similar but less frequent spread to the liver, spleen or kidney has also been noted. It is particularly the thoracic and abdominal varieties of actinomycosis which give rise to blood stream invasion. Because of the remarkable invasive features of actinomycosis by which the disease spreads by direct extension, involvement of the liver and spleen may occur in either abdominal or thoracic actinomycosis by direct migration without the agency of blood stream metastasis.

In a fairly large number of cases of isolated actinomycosis of the urinary bladder, the female generative organs, the kidney and even bone the origin remains uncertain. As was suggested above undoubtedly some of these may have their origin in so called abdominal actinomycosis, presumably being the residuum of an actinomycotic process which migrated out from the intestinal canal. It is possible that actinomycosis reached these organs by direct spread from an actinomycotic focus which had its origin elsewhere than in the intestinal canal. The

instances of isolated actinomycosis of the stomach which have been observed undoubtedly have their origin in the ingestion and direct lodgment of actinomycetes in the stomach.

Extension from cervicofacial actinomycosis may occur into the thorax by way of the supraclavicular fossa, and invasion of the cranium may occur through the orbit, by way of the foramina at the base of the skull or by direct erosion of bone. The importance of early recognition and adequate treatment of the lesion to obviate these unfortunate occurrences is immediately apparent.

obtained from a sinus or recovered by curettage at operation is put out on gauze or placed in water, where the granules may be identified more readily. Suspicious-looking granules are placed on a glass slide in a drop of strong potassium hydroxide, and this wet preparation is examined immediately. The sulfur-like granule of an actinomycotic colony is shown in Fig. 11, A. A coiled group of intertwined mycelial threads terminating in clubs is the typical picture. When fistulization has already occurred and drainage of exudate is slight, curettage of the sinus followed by paraffin embedding and staining with hematoxylin and eosin

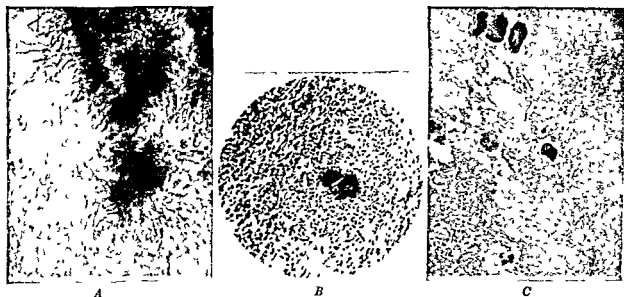


Fig. 11—A, Sulfur granule (Gram's stain,  $\times 250$ ), this is the typical ray fungus rosette. The conformation of the twisted mycelial threads is shown B, a number of actinomycetes colonies surrounded by leukocytes. The organism is gram positive C, Gram's stain of a sulfur granule, showing the intertwining mycelial threads of the streptothrix ( $\times 250$ ).\*

**Diagnosis.**—That actinomycosis of the thorax or abdomen may not be identified early is obvious, why actinomycosis of the cheek or neck should not be recognized early is difficult to understand. A lesion which may be seen and palpated should suggest invoking aids to affirm or deny the presence of actinomycosis. Mere consideration of the possibility of the lesion goes a long way toward its identification if every lead is pursued to its logical conclusion.

The determination of the actual presence of actinomycosis rests upon bacteriologic means. The exudate recovered from an area of softening by needle aspiration or exudate

of a cut section will usually succeed in demonstrating the organisms when they cannot be identified in the exudate (Fig. 11, B and C). When sinuses have long been present in actinomycosis, the organisms may be difficult to find. They are most readily found in a lesion which has not been drained.

**Differential Diagnosis.**—*Cervicofacial Actinomycosis*—Patients may acquire the disease at any age, but the majority of patients are adults. Persons of middle age who have the disease usually are thought to have a malignant growth; in younger persons the

\* Warrentzen: Ann Surg 104; J B Lippincott Co

most frequent diagnosis is tuberculosis of the lymph nodes. The trismus of the muscles of the jaw and the induration of the cheek and neck with discharging sinuses frequently suggest the picture of late intra-oral malignant disease. If the mouth can be opened adequately for examination the absence of an ulcerating lesion should at once give increased credence to the belief that the lesion is probably actinomycosis. Malignant disease, tuberculous lymph nodes or osteomyelitis of the jaw and suppuration in a branchial cyst may mimic the appearance of this variety of actinomycosis. The finding of the organism establishes the nature of the lesion.

**Thoracic Actinomycosis**—Early recognition of the lesion is likely to be accidental. In my own experience it is the occurrence of an empyema which is threatening to rupture through the thorax in the vicinity of the breast on the anterior chest wall which gives the first indication of the presence of thoracic actinomycosis. Kirklin and Hefke (1931) have indicated that the roentgenologist may occasionally diagnose the lesion when the lung, pleura and chest wall are involved; that is an intrapulmonary lesion which simultaneously gives rise to periostitis should suggest actinomycosis. The clinician usually will suspect the presence of the lesion before the roentgenologist will be able to suggest the possibility of its presence from roentgenograms of the chest. Free bleeding following probing of a thoracic sinus tract may suggest the possibility of actinomycosis. Pulmonary abscess, bronchiectasis with abscess or carnification of the lung, tuberculosis, malignant disease of the lung or pleura, pyogenic empyema, unresolved pneumonia, syphilis of the lung, blastomycosis and hydatid cyst may give rise to confusion.

**Abdominal Actinomycosis**—In most instances patients with abdominal actinomycosis are operated upon for appendicitis. Exudate may be found around the appendix, the true nature of the lesion remaining wholly unsuspected. An intestinal fistula may form or an abscess may appear in the incision subsequent to complete healing. The late occurrence of a subhepatic, subdiaphragmatic or perirenal abscess necessitating drainage may be the means by which

the process is identified. Any sinus which develops spontaneously in the abdominal wall should be looked upon with suspicion. Carcinoma, particularly in the cecum, Hodgkin's disease, appendiceal abscess and its complications, tuberculosis of the bowel and peritoneum, so-called regional ileitis with abscess formation, perinephric abscess and chronic granulomas are the ordinary conditions with which abdominal actinomycosis may be confused. Shiota (1909) related that localized actinomycosis had been cured by appendectomy or intestinal resection. Cure after gastric resection in which actinomycosis was discovered histologically, has been reported in a few instances. Similar cures have attended drainage of a subdiaphragmatic or pelvic abscess, actinomycotic in nature, which in all likelihood had its origin in an ileocecal lesion. Like results have attended excision of an actinomycotic kidney, as well as excision of an abscess of the fallopian tubes or ovaries or a process in the uterus which was found to be actinomycotic.

**Treatment**—Actinomycosis has been known as a disease entity affecting man for almost sixty years. During this time a large number of agents have been recommended and tried in combating the disease. Only three have enjoyed wide usage, viz., surgical treatment, potassium iodide and irradiation. Among other remedies less frequently employed the following may be enumerated: vaccine therapy, methylene blue, copper sulfate, neoursphenamine, thiomol and injections of foreign protein.

Roentgen therapy of actinomycosis first employed by Harsha (1901) of Chicago did not gain many adherents until after Levy of Breslau again advised its use (1913). Its endorsement by New and Figg (1923) and Heverdahl (1927) of Oslo have led to its wide employment in the treatment of this condition. That the method has virtue is attested to adequately in the numerous papers extolling the remedial properties of this therapeutic agent. The manner in which it operates is not clear. Kleesattel and Ingber (1928) have both indicated that roentgen ray or radium has no effect upon the organism. One cannot read the papers of Heverdahl (1927) and Engelstad (1932) and escape the impression that irradiation



has real merit. Roentgen therapy probably promotes fistulization and thereby accelerates healing.

The employment of potassium iodide in the treatment of human actinomycosis originated from veterinary medicine (1892). Veterinarians since have learned that potassium iodide is of no value in the treatment of *Actinomyces bovis*. In actinobacillosis, a disease of cattle and swine which mimics the pathologic aspects of true actinomycosis, potassium iodide acts as a specific terminating the disease. Actinobacillosis in man, on the contrary, has only rarely been observed. That the administra-

tion of the debris of the dead tissue which the diseased process brings about in which the oxygen tension is zero, the organisms thrive and are carried off by the macrophages into the healthy tissue in their attempt to combat the disease. Here again new abscesses develop with death of more tissue and the establishment of new areas of low oxygen tension which constitute favorable culture media for the perpetuation of the disease. What is obviously needed is excision of these areas of dead and dying tissue which propagate the disease. Surgical treatment has been the mainstay in dealing with actinomycosis in our clinic for fifteen years.



Fig. 12.—Actinomycosis in a girl aged 13. After two curettements, complete healing resulted.\*

cure are on record particularly of abdominal actinomycosis. More recently, the sulfonamides have been employed with some success in complicated forms of the disease. Sulfanilamide and sulfadiazine appear to have particular merit. DeBakey<sup>2</sup> reports that penicillin too is of real value in actinomycosis. In all abdominal or thoracic forms of the disease, therefore sulfonamides and penicillin should be employed in addition to surgical evacuation of dead tissue.

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#### BLASTOMYCOSIS

(*Blastomycetic Dermatitis Saccharomyces Hominis Dermatitis Blastomycotica Hefenmycose*)

**Definition.**—Blastomycosis may be either cutaneous or systemic. Cutaneous blastomycosis is a chronic inflammatory infectious skin disease characterized by the development of papulopustular lesions which extend peripherally and form variously sized elevated verrucous patches with sloping borders.

**Etiology.**—In most cases there has been a history of preceding trauma. Presumably infection occurs only after an injury. The majority of cases occur in men. There is, however, no relationship between the disease and sex. Fifty per cent of the cases

occur after the age of forty; the remainder between the ages of twenty and forty. It has been observed in younger and older patients. The disease is uncommon except in the neighborhood of Chicago. Most of the cases have developed without any history of association with other cases. Guinea pigs and rabbits have been successfully inoculated with the organism. The causative organism is a blastomycete or yeast, a species of fungus which multiplies by a process of cell division called budding. It is a round, oval or irregularly shaped body from 7 to 20  $\mu$  in diameter with a well defined double contoured capsule and a fine or coarsely granular protoplasm separated from the capsule by a clear space of varying width. To isolate the organism in a suspected case a small abscess situated in the sloping border of the lesion, not from the verrucous center, is punctured with a platinum pointed needle and a small amount of pus from it is smeared on a glass slide. To this is then added a few drops of a 25 to 40 per cent solution of potassium hydroxide. A cover glass is placed on top and the slide allowed to stand for a few minutes. It is then examined with the high power of the microscope and the diagnosis is made on finding the organism preferably in budding forms.

**Histopathology.**—Histologically the lesions resemble those of verrucous tuberculosis and superficial epithelioma. The epidermis is throughout the seat of marked hyperplasia. The acanthosis is similar to that seen in the histology of venereal warts. The prickle cell layer is markedly edematous; the interepithelial lymphatic spaces are dilated and polymorphonuclear leukocytes in various forms can be detected between the cells. In the epidermis, milium abscesses are present which contain polymorphonuclear leukocytes, eosinophils, epidermal debris and usually several blastomycetes arranged singly, in pairs and in budding formation. In the corium there is a diffuse cellular infiltration occupying the upper layers consisting of plasma cells, connective tissue cells, polymorphonuclear leukocytes, lymphocytes and a few giant cells. The collagen and elastin have lost their definition; they stain feebly and where the infiltration is densest they may have completely disap-

peared. The blastomycetes are found in military abscesses between the epithelial cells and in the corium rarely within the cells. Giant cells usually contain one or more organisms.

**Symptoms**—The disease begins most often following an injury even a trifling one as a papule or papulopustule which slowly enlarges peripherally to form a wart-like papule and this in turn enlarges to become a verrucous patch definitely elevated from  $\frac{1}{8}$  to  $\frac{3}{8}$  inch above the skin. A typical patch is generally bluish red and

cessible to the face hands wrists forearms and eyelids. In the average case there may be several lesions but in many cases there may be a large number. The course of the disease is chronic. Although patches may apparently begin to heal even without treatment some areas are very refractory and recurrences are common even under the most intensive therapy.

**Systemic blastomycosis** is that type of the disease which affects the internal organs principally the lungs liver, kidneys and spleen and also the bones.

The chief symptoms are an irregular fever ( $103^{\circ}$  F.) loss of appetite emaciation and general weakness. In this type of disease the cutaneous manifestations differ from those seen in cutaneous blastomycosis. Subcutaneous nodules and abscesses which later develop into ulcers are commonly seen and bony abscesses occur with complete destruction of the involved bone. In these cases the pus from the abscess cavities discloses the organism.

**Diagnosis**—The diagnosis of cutaneous blastomycosis is made on finding budding yeastlike organisms in the small abscesses on the edges of the lesion.

**Treatment**—The treatment of blastomycosis is principally medicinal. The best results have been obtained by the administration of potassium iodide in large doses. The patient is given a saturated solution of the drug and instructed to begin treatment with 10 drops well diluted in water three times a day and to increase the dosage by 1 drop at every dose until involution of the lesion begins. That dose is then maintained. In resistant cases injections of napharsen or neoarsphenamine at the same time seem to be of considerable benefit in enhancing the activity of the iodide. When this therapy is resisted surgical excision of individual patches can safely be done. Flectrocoagulation and excision with the cutting current have also been used successfully.

Wet dressings of a 1 per cent copper sulfate solution are one of the best forms of topical medication. Tincture of iodine and saturated solution of gentian violet have also proved to be of value as topical applications.

The disease is very stubborn but begins to respond quickly to iodide therapy. It is



Fig. 13—Blastomycosis

covered by a bulky and adherent crust the removal of which shows a surface distinctly verrucous covered with papilliform elevations bathed in pus. The sloping borders vary in width from  $\frac{1}{4}$  to  $\frac{3}{8}$  inch and on close inspection can be seen to be the seat of minute abscesses in which the organism is found. The average patch in several months may attain the size of a silver half dollar (Fig. 13). It may often remain indolent for some time but sooner or later it will start to spread. In the course of several weeks or months new plaques will form in the neighborhood of the old one which fact strongly suggests the possibility of autoinoculation. Another point in favor of autoinoculation is the location of the regions most commonly involved those most ac-

imperative to continue treatment until all signs of the disease have disappeared. Treatment in the systemic cases has so far proved of little value, and the prognosis is very grave. The mortality rate in that type of the disease is 90 per cent.

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### COCCIDIOIDAL GRANULOMA

(*Coccidioidomycosis*)

**Definition.**—Coccidioidal granuloma is an acute or chronic infection caused by a specific fungus. Most of the examples of the disease are observed in the San Joaquin Valley of California. A mild form of the infection is seen in the endemic area, the patients recovering without complications. Subcutaneous abscesses, verrucous skin lesions and meningeal, respiratory, osseous or other involvement may be observed in chronic cases.

**Etiology.**—The causative fungus is *Coccidioides immitis*, which has a double life cycle. The *parasitic stage* is seen only in the host, where the fungus reproduces by endosporulation. The organism appears as a round, highly refractile, double-contoured capsule with an average diameter of 30 microns. Reproduction is by endogenous sporulation only. When the spores are mature, the wall of the capsule ruptures, and the spores escape to continue the cycle. Absence of budding differentiates it from blastomycosis. The *vegetative cycle* develops on all kinds of culture mediums as a white cottony growth. Arthrospores and chlamydospores only are formed in culture. The mold has been isolated from the soil in endemic areas. Infection is not possible in the absence of chlamydospores. In the dry season this fungus is blown about in the dust and inhaled by man. If local infections do occur, they are very unusual. The introduction of the

spores by trauma from contaminated thorns or twigs may produce local disease. It is pathogenic to cattle, sheep, guinea pigs,



Fig. 14—Coccidioidal granuloma. Subcutaneous abscesses on forehead and at sternoclavicular junction.



Fig. 15—Coccidioidal granuloma. Verrucous type which clinically resembles blastomycosis.

monkeys and man. Man to man or animal to man transmission has not been observed.

**Histopathology.**—The *Coccidioides immitis* organism has been shown to invade every organ in the human body except the intestinal tract. It creates a pathologic pic-

ture similar to that seen in tuberculosis the lesions in coccidioidomycosis showing a greater tendency to suppuration than the lesions of tuberculosis. Cutaneous involvement is in the deep cutis and is generally secondary to a systemic infection.

The characteristic lesions have a tubercle-like formation with some central necrosis and giant cell formation. The surrounding infiltrate consists of lymphocytes, plasma and epithelioid cells. The organism may be found in the giant cells or scattered throughout the cellular infiltrate. A positive histo-

disease may be the result of a recently acquired infection or a late manifestation of an infection acquired in childhood. In this and many other respects the disease closely resembles tuberculosis.

The early cutaneous lesions of coccidioidomycosis are often observed on the exposed parts of the body: subcutaneous abscesses, verrucous lesions, granulomatous nodules or indolent ulcers being observed on the skin. Destruction of bone, lymph node involvement and meningeal manifestation are less frequently found. Pain is not a prominent



Fig. 16.—Mature double-contoured organism of coccidioidal granuloma in tissue.

pathologic diagnosis cannot be made unless the double-contoured endospore-forming organism is found.

**Clinical Manifestations.**—An infection with *C. immitis* may manifest itself in various ways. A primary acute infection of the respiratory tract, sometimes associated with erythema nodosum, has been recently described under the name of San Joaquin Valley fever. This type of involvement is more prevalent among children and new residents of the endemic area and presents a definite problem for the military forces stationed in the San Joaquin Valley. There is a fulminating type of respiratory involvement generally observed in adults which may terminate fatally in six to eight weeks. Most examples of this form of the disease are seen in new inhabitants of the endemic area. The sub-acute or chronic granulomatous form of the

symptom except in cases of bone or meningeal involvement.

There is usually low grade fever in these cases with moderate leukocytosis; the count being 10,000 to 15,000.

**Diagnosis.**—Coccidioidal granuloma must be differentiated from tuberculosis, syphilis, cancer, blastomycosis and the other deep mycoses. The clinical and pathologic manifestations of coccidioidal granuloma, tuberculosis and blastomycosis are so similar that a differential diagnosis can be made only by laboratory methods. Pus, sputum, bone scrapings, spinal fluid or tissue may be examined. The double-contoured endospore-forming organism must be demonstrated in pus or tissue or in laboratory animals. The final diagnosis rests upon the demonstration of both the parasitic and the vegetative cycle.

The *coccidioidin* test is analogous to the tuberculin test. Its specificity is generally accepted by most investigators. However a diagnosis should never be made on this test alone but the results may be of considerable value as confirmatory evidence. Complement fixation and precipitation tests are aids in diagnosis and prognosis. It has been shown that 69 per cent of a group of children over fifteen years of age in the endemic area reacted positively to the test.

**Prognosis**—Most of the patients with primary acute coccidioid infection of the respiratory tract recover spontaneously in four to six weeks. In the granulomatous type of the disease the mortality is approximately 50 per cent.

**Treatment**—The general treatment in cases of chronic or acute fulminating coccidioid granuloma should be the same as for tuberculosis. Rest, sunshine and good food will generally accomplish more than other measures. Many drugs have been used but only antimony and potassium tartrate, thymol and colloidal copper seem to have given some therapeutic results. Sulfaamide and other related products have not been found to be of value. Vaccines have been reported to be of use in some cases and roentgen therapy has been effective in a few instances.

Abscesses may be incised and drained. A few cases have been reported in which amputation of an infected extremity has cured the disease. Most patients have a systemic infection and surgical treatment or other local therapy is only palliative.

In endemic areas patients with mild systemic infections generally recover without treatment.

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#### TULAREMIA

**Synonyms**—Francis disease, deer fly fever, rabbit fever, Ohara's disease, wild rab-

bit disease, the first American disease, plague like disease of rodents, glandular type of tick fever and alkali disease.

**Definition**—Tularemia is an infectious disease caused by *Bacterium tularense*.

**Etiology**—*Bact. tularense* first isolated in 1911 by McCoy and Chapin from ground squirrels (*Citellus beecheyi*) dead or dying from a plague like epizootic in Tulare County, California, was named after the county in which the discovery was made. It is the cause of a fatal bacteremia of rodents, especially wild rabbits and hares. The infection is transmitted to man (1) by the bite of an infected blood sucking fly, the horse fly (*Chrysops discalis*) (Williston), commonly found on horses and cattle, which also bites rabbits and man, (2) by the bite of the wood tick (*Dermacentor andersoni*) (Stiles) by the bite of a tick (probably *D. variabilis*) or by contamination of the hands or conjunctival sac with the internal organs or body fluids of infected rodents, flies or ticks, and by the bites of animals. The name tularemia was given to the disease on account of the presence in the blood of the causative *Bact. tularense*.

**Epidemiology**—Human cases of the disease have been reported from the District of Columbia and all of the states of the Union and also from Norway, Sweden, Russia, Japan and England. According to a public health report (1940) there were in the United States 2,088 cases with 190 deaths during 1939. In 1940 there were 2,900 cases with 150 deaths (approximate returns incomplete). Wild rabbits and hares are the direct cause of more than 90 per cent of human cases in the United States. Horseflies have caused 68 cases in Utah and the surrounding states. Wood ticks have caused 53 cases in Montana and the surrounding states. Sheep contact has caused 12 cases in the Northwest. Insect bites (species undetermined) have caused 9 cases, tree squirrels 14 cases and opossums 9 cases. One case each followed skinning or dressing a sage hen, coyote, deer, red fox and bull snake. Two cases each followed like contact with quail, ground hog, muskrat, hog and skunk. Eleven were caused by scratches or bites from cats. Eating insufficiently cooked rabbit meat caused 20 cases with 12 deaths. The disease shows marked seasonal variation.

tions in different parts of the United States. In the West the incidence corresponds with the time of the greatest activity of the wood ticks (March to August) and deer flies (June to September) and to the time jack rabbit hunting is greatest (spring summer and early fall). East of the Mississippi the incidence is limited almost entirely to the open season for hunting wild cotton tail rabbits (November December and January) (Simpson). The disease occurs chiefly in persons who skin and dress rabbits hunters market men and cooks. No abrasion of the skin is necessary as a portal of entry for the infection. All ages are susceptible. The age limits of reported cases range from two to seventy three years. One attack is believed to confer lasting immunity. There is no evidence that the disease is contagious from man to man. No instance has been reported of the spread of the disease from man to man by mere contact or by an insect's biting a patient and then another person. Only one case is on record (Harris) in which the primary lesion developed in a skin abrasion in a person dressing an open ulcer of a patient with tularemia. One case is reported of a man who had his finger pecked by a chicken hawk which he shot while it was feeding on a dead rabbit. The man did not touch the rabbit.

**Pathology**—*In Man Acute Lesions*—1 A primary ulcer shows a diffuse necrosis with nuclear fragmentation and infiltration with polymorphonuclear leukocytes beyond which there is a zone of infiltration with small lymphocytes. 2 Affected lymph nodes show focal and diffuse necrosis. 3 The spleen shows on its surface and throughout its pulp necrotic foci bordered by normal splenic pulp. 4 The liver shows small necrotic foci. 5 The lung shows small necrotic foci on the pleural surface and cut sections show small areas of focal necrosis bronchopneumonic patches or consolidation of almost an entire lobe (alveolar pneumonia).

**Subacute Lesions**—Subacute lesions are characteristic of the lesions after the end of the second week. Histologically areas of focal necrosis show a central caseous zone surrounded by a zone of epithelioid cells and fibroblasts arranged radially and a peripheral zone of lymphocytes among which there

may be a few giant cells. The picture resembles that of tuberculosis.

*In laboratory animals* inoculated for diagnostic purposes death usually occurs within a week. Cessation of the enlarged lymph nodes and numerous discrete areas of focal necrosis are found studded over the enlarged spleen especially and over the liver. The lesions are often minute and for this reason the organs should be viewed in direct sunlight or under strong electric lights. It is also well to use a hand lens. The appearance is characteristic and is well described by the terms spotted spleen and spotted liver.

**Symptoms**—There are eight clinical types of the disease. (1) *Ulceroglandular*. A primary lesion a painful red papule which later becomes a pustule the center becomes necrotic and is liberated leaving a circumscribed punched out ulcer with a reddened periphery. The ulcer is persistent and does not respond to treatment with antiseptic dressings later breaking down to form an ulcer of the skin accompanied by enlargement of the regional lymph nodes by far the most common type. (2) *Oculoglandular*. The primary lesion is conjunctivitis accompanied by enlargement of the regional lymph nodes. (3) *Glandular* without any primary lesion but with enlargement of regional lymph nodes. (4) *Typhoid or septicemic* no primary lesion or enlargement of lymph nodes. (5) *Ingestive*. (6) *Pneumonic* (bronchial or lobar). (7) *Meningitic*. (8) *Anginal Fulminant* cases rapidly fatal occur in types 1 2 3 6 and 7.

**Incubation**—The incubation period varies from one to ten days usually it is two three or four days. The average period is about three and one-half days. The onset often occurs during sleep or while the patient is at work and is characterized by gripe like symptoms.

**Onset**—A sudden onset is characteristic with severe headache fever chilliness or repeated chills profuse sweating aching pains in the back and extremities marked prostration and sometimes vomiting and diarrhea. *Fever* is always present in cases of tularemia and shows a characteristic curve. The initial temperature ranges between 101° and 103° F and as a rule is septic in character. It lasts one two or three days followed by a fall and then a *secondary rise* to the orig-

mal height after which it *gradually declines to normal* at the end of from two to three weeks. In the glandular types there is only a moderate increase in the pulse rate, as a rule to about 90 and practically no increase in the respiratory rate. The early remission of temperature is accompanied by the diminution of all symptoms and the patient often believes he is well but soon the symptoms return and there is a *secondary rise* of the temperature. There is *moderate leucocytosis* (possibly 16 000 leukocytes) but it is of no diagnostic importance. In some cases skin eruptions occur on the arms and neck on the trunk and on the abdomen they are maculopapular papular papulopustular, with a few vesicles and eventually scaling erythema multiforme like and scarlatiniform. The skin eruption in itself, does not aid in the diagnosis.

Most cases show a considerable degree of chronicity. Convalescence is slow and is characterized by fatigue. It may require six months to a year for the patient to regain his normal strength. Recovery is usually without sequelae. *Complications* are unusual.

**Prognosis**—The mortality rate is rather low in cases of tularemia ranging from 10 to 4 or 5 per cent in the United States. Symptoms and findings of pneumonia meningitis or peritonitis are bad prognostic signs. Once over the disease the patient is immune.

**Diagnosis**—The diagnosis is based on (1) the patient's history of having handled wild rabbits or having been bitten by a tick or fly (2) a primary lesion of the skin beginning as a painful papule or pustule followed by a persistent ulcer or by a primary conjunctivitis followed often by ulcers of the conjunctiva, (3) persistent firm tender glandular enlargement at times quite painful in the regional lymph nodes and (4) fever of from two to three weeks' duration.

The diagnosis is confirmed (1) *earliest* by *Foshay's intradermal test*. An intradermal injection of a vaccine of a clinically detoxified dilute suspension of *Bact. tularensis* causes a local reaction—a simple erythema. The test is absolutely specific; it proves the presence of the disease; it is positive in all cases from the second day to the fifteenth month and it is especially useful during the first twelve days when agglutination tests are

usually negative. It has not been found to be positive in any other disease. The test becomes negative only when the disease is completely cured. (2) The *agglutination test* is useless during the first week or ten days but always becomes positive during the second week and the agglutinins reach the highest titer during the third week (Dickey). Thereafter it is highly specific and is the simplest and probably the best method of confirming the diagnosis. With the exception of an occasional cross agglutination of *Bact. tularensis* and the *Brucella* organisms the agglutination reaction for tularemia is highly specific. Agglutinins persist in the blood for many years (Dickey). (3) The diagnosis may be confirmed by *animal reproduction of the disease with isolation of Bact. tularensis* from guinea pigs rabbits or white mice inoculated with the blood of the patient during the first days or with material taken as early as the first week from the primary lesion or from the enlarged regional lymph nodes at the time of spontaneous or surgical drainage. It is seldom successful for weeks or more after the patient is infected. Pus from the patient's lesion (primary or suppurating lymph nodes) is rubbed in a mortar, suspended in salt solution filtered through coarse gauze and injected subcutaneously into the abdominal wall of a guinea pig or rabbit. Blood is defibrinated and mixed with an equal amount of normal saline solution and from 4 to 8 cc is injected intraperitoneally into the guinea pigs. Dickey states that the organism can be grown in mediums containing cystine but it grows very poorly or not at all in routine blood agar and brain broth.

**Differential Diagnosis**—The diseases which must be considered in making a differential diagnosis include climatic bubo (rodent) resulting from a rat bite influenza pneumonia typhoid fever, septic influenza sporotrichosis undulant fever meningitis, peritonitis from other causes Parinaud's conjunctivitis and conjunctivitis necroticans infectious erythema multiforme malaria and tuberculosis. Dickey points out the importance of keeping the pneumonic type in mind when one realizes the frequency of pulmonary complications in tularemia. Although the seriousness of tularemic pneumonia is not to be denied the present tendency is to



consider it less fatal than previously recorded. Early treatment with an antiserum has helped produce this change in opinion. Any atypical pneumonia with a relatively low white blood cell count, a slow pulse rate and slow evolution of lung changes should cause one to suspect tularemia. This disease must also be considered in cases of pleurisy with effusion. A chest roentgenogram should be taken in every case of tularemia.

**Prophylaxis** is the most important phase of treatment. 1. Wild rabbit should always be thoroughly cooked so as to render any infected meat harmless for food. 2. Laboratory workers and all persons who handle wild rabbits should wear rubber gloves. Patients with tularemia do not require isolation or quarantine but persons who dress tularemic lesions should wear rubber gloves and should use ordinary disinfectants on their hands. 3. The most important recent advance is *vaccine prophylaxis* (Foshay et al.)—the administration to susceptible individuals of 3 doses of 0.5 ml each of a vaccine injected subcutaneously and alternately into the arms on either consecutive or alternate days completing the administration within a 6 day period to avoid sensitization reaction. A study of 2145 persons so vaccinated showed that definite protection was obtained and those who did acquire tularemia exhibited significant amelioration and shortening of the disease. Such protection lasts about one year, seldom longer, sometimes less. Consequently re-vaccination is advised at least annually when exposure is seasonal, every three or four months with small doses during the period of exposure where exposure is anticipated throughout a period of several months or longer. Prophylactic vaccination is best completed at least three weeks before the anticipated exposure but there need be no fear of inducing harmful effects by administering vaccine immediately prior to exposure or during the incubation period.

**Treatment**—Confinement to bed is of utmost importance during the acute stage of the disease as long as the fever lasts. *The primary lesion should never be incised.* The enlarged lymph nodes should never be excised or even incised until suppuration is advanced until the mass definitely fluctuates and the skin overlying the mass is thin

and about to rupture spontaneously. Then only a very small incision is indicated. If the patient is seen early and properly treated suppuration of lymph nodes should not occur.

Early active treatment includes the use of *convalescent serum*, the patient receiving a transfusion of from 200 to 500 cc of blood from a compatible donor who has completely recovered from tularemia. This treatment appears to arrest the progress of the disease, but not enough experience has been accumulated to justify the making of definite conclusions.

A *specific antiserum* prepared from vaccinated goats has been developed and used by Foshay. The beneficial effects appear soon after its administration. Within twenty-four hours there is usually complete relief from headache and a marked diminution in the intensity of the general malaise, arthralgia and myalgia. The ulcers become less painful and healing is well under way before the end of a week. The temperature rapidly falls, the enlarged lymph nodes quickly diminish in size and if treatment has been early enough suppuration does not occur. The antiserum should be given as early as possible in order to prevent glandular suppuration and also death from the septicemia.

Serum therapy definitely shortens the duration of the primary lesion, fever, hospitalization, lymphadenopathy, disability and course of the disease. Unpreserved serum is far more potent than that containing any preservative. Two doses of 15 cc each given intravenously on successive days are far more effective than only one dose or than two doses administered subcutaneously or intramuscularly. In cases of the typhoid type or cases of the ulceroglandular type in which the enlarged nodes measure more than 5 cm in diameter the patient should be given daily doses for three or more successive days or perhaps larger amounts. Later workers have used 0 cc the first day and 90 cc the second day. Rubnitz warns that antitularemic serum frequently causes anaphylactic reactions, that the usual precautions should be taken to avoid reactions and that serum sickness does not always manifest itself by an urticarial or erythematous rash but swelling of lymph nodes, joint and muscle

pains, headache and fever may develop. These symptoms may be mistaken as indicating a relapse and more serum may be given, with disastrous results. He suggests that serum treatment be reserved for serious cases. When there is evidence of sepsis and visceral involvement, serum therapy may offer the only hope and larger doses should be given. The initial dose may be as high as 90 cc; this should be followed by injections of 30 cc every 8 to 12 hours until definite improvement is noted. Live anti-tularemia serum has been found to be effective and easy to administer (Ginn, Toman and Marr). Sulfu drugs have been used with varying success. Some observers among them Moss and Weilbaecher (1941) report rapid clinical improvement in several severe cases while others including Shaffer (1943) report lack of response. Loria reports the use of acriflavine with marked success in 3 cases, 100 mg of acriflavine dissolved in 250 cc of normal saline solution being administered every 72 hours for three or four treatments. However, he believes that further observations on the use of this drug in tularemia are necessary before its efficacy can be definitely evaluated. Josey reports the use of 1,900,000 Oxford units of penicillin intramuscularly in a case of pneumonic type tularemia without any beneficial effect.

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## IV. THERMAL, CHEMICAL, ELECTRICAL AND IRRADIATION INJURIES

### THERMAL BURNS

Thermal burns have been a conspicuous cause of death in civilian disasters and modern warfare. They will remain a surgical problem as long as petroleum and illuminating gas are used for motive power and heating and as long as buildings are made of inflammable material.

World War II accompanied by an increased incidence of thermal burns has challenged the surgeon's mode of handling them and their complications—shock, infection and malnutrition—and with the aid of materials such as plasma and chemotherapeutic agents, avowedly the mortality has been reduced. Up to 1941 it was conceded that a burn involving more than 50 per cent of the body surface would prove fatal. Now a patient with a burn of more than 70 per cent, even if the greater proportion is full thickness, is not doomed.

It would be fallacious to ascribe to the impetus of World War II the entire improvement in burn treatment for ever since World War I knowledge regarding the nature of burns had been accumulating. Progress in the therapy of burns has been thwarted by the surgeon's narrow habit of concentrating on the wound. A broader point of view emerged from the study of shock in World War I. Underhill and Davidson, under this influence, made the first contribution to the therapy of burn shock by pointing out the fluid and electrolyte deficiency. A decade later Blalock and Harkins measured the protein loss from the blood stream into the wound which controls fluid and electrolyte distribution. Elman introduced plasma transfusion. Finally Fier and Aldrich conceived of the early influence of infection in burn shock.

The rationale of the treatment of burns is dependent upon what is known of their pathologic anatomy and physiology.

### NATURE OF THE WOUND

The application of sufficient heat to a body surface to create a burn precipitates a

chain of events including pain, alterations in blood flow, increased capillary permeability, edema and increased lymph flow. To these physiologic changes is usually appended some degree of cell necrosis.

**Pathologic Anatomy**—It is essential for purposes of treatment to record the extent and the depth of the burn, necrosis and whether the epidermis is intact. Burns are classified according to the depth of the necrosis into three categories: first, second and third degree. (The Dupuytren classification with six categories is unnecessarily cumbersome.) The first degree burn is mild and of such superficial nature that blebs do not form. The burned area is indicated by the dilated capillaries and edema of the skin. Visible necrosis may be absent but usually such a burn is followed by peeling of the superficial part of the epidermis. Healing originates in the germinating layer of the epidermis and is completed within a few days without a scar.

The term *second degree* denotes a burn with necrosis extending into the derma but with viable epithelial remnants; this wound will heal without grafting. By definition the second degree burn involves the entire epidermis but varying depths of the derma. It is good practice to divide the category of second degree burns into superficial and deep. Superficial burns epithelialize rapidly from the numerous gland crypts and hair follicles near the surface, even in the presence of an intact dead epidermis and bleb fluid. Healing without scarring is expected within two weeks. In the deep second degree burn there are fewer epithelial remnants for regeneration and the tough fibrous slough must be shed before the cells can blanket the surface. During the process of slough cleavage there may be considerable fibrous tissue proliferation. Healing is therefore tedious and there will be scarring.

Second degree burns are most easily detected by the blubbing which occurs. Blebs form in the deep epidermal layer or between epidermis and derma but not in the derma.

itself presumably because of the presence of abundant tough collagen in the fibrous stroma. Blebs enlarge as the pressure of edema fluid rises and are not seen immediately. Blebs do not form in the deep second degree burns where the heat coagulates the superficial layers of the wound. This is particularly true in the portions of the body where the skin is thick—the buttocks, upper thighs and lower back. In these areas the surface appearance of the wound may resemble that of a third degree burn.

*Third degree or full thickness* designates those burns in which the skin and all epithelial elements are destroyed. Epithelialization can start from the periphery or grafts only after the slough has been eliminated. Spontaneous elimination requires three to five weeks. Such wounds are disclosed by either a charred or blanched coagulation of the tissues which have no circulation. Blebbing is rare. They may be further identified by lack of local pain and sensation since presumably the sensory nerve endings in the skin have also been destroyed.

It is sometimes impossible to ascertain the depth of skin necrosis particularly immediately after the burn before the edema has completely formed. During the period of pain a superficial second degree burn may be white owing to arteriolar constriction and may resemble a third degree wound. Nothing better than the eye has been devised with which to distinguish the depths of skin necrosis.

The extent of the burn is best computed in the percentage of total body surface using the scale of Berkow as given in the accompanying table.

Flames and hot gases may burn the respiratory tract as low as the trachea and edema may produce laryngeal obstruction. The damage most to be feared in the respiratory tract is that to the bronchiolar epithelium caused by irritant gases from a conflagration in an enclosed space. Bronchiolar spasm, edema and epithelial denudation may result in respiratory obstruction and death.

In burns about the face the eyes occasionally are damaged. Deep corneal necrosis is rare.

**Pathologic Physiology.**—*Pain*—Acute pain is elicited in the sensory nerves of the

# THE BERKOW\* SCALE FOR ESTIMATING EXTENT OF BURNS

	Body Surface Percentage
Head and neck	6
Trunk	38
<i>a</i> Ant. trunk and genitals	20
<i>b</i> Post. trunk	18
Upper extremities	18
<i>a</i> Hands	4.5
<i>b</i> Arms	13.5
Lower extremities	39
<i>a</i> Feet	6.3
<i>b</i> Legs	12.6
<i>c</i> Thighs including buttocks	19
For children under 12 the figures are	
Trunk and genitals	40
Upper extremities	16
Head and neck	6+ (10— age)
Lower extremities including buttocks	39— (10— age)

skin by heat but also in the damaged vascular bed if the intracapillary pressure is raised. Prompt relief is obtained by cooling an effect produced in part by a decrease in blood flow.

**Increased Blood Flow**—The blood flow to a burn and its immediate vicinity is augmented partly by direct trauma to the small vessels within the wound and partly perhaps by reflex dilatation of the vessels beneath the wound. (Initially there is transient blanching of the skin or decrease in flow, which may be prolonged for minutes by a pain reflex.) The increased flow is a component of the inflammation of the wound and persists until the wound is healed.

**Increased Capillary Permeability**—The capillaries become more permeable in the burned area; a protein rich plasma filtrate pours out distending the interstitial spaces. The edema thus produced may involve not only the skin but also the more readily distensible subcutaneous tissue. The visible cutaneous edema therefore may not be a true indication of the volume of fluid which has

\* Berkow, Am. J. Surg. 32

escaped from the blood stream. Hence the extent of the burn rather than the depth, is a guide to the volume of the fluid lost.

The integrity of the capillary wall is not entirely destroyed in those capillaries of the wound in which the circulation is maintained and through which the edema fluid exudes. The edema fluid of burned patients has not been measured directly, what is known about it is derived from measurements on bleb fluid. It is assumed that bleb fluid is a close approximation to edema fluid since there is evidence of a constant interchange. Red blood cells do not escape from the capillaries and part of the protein, principally the globulin fraction, is retained. The average protein concentration of bleb fluid in the first two days after the burn is 4.0 Gm. per hundred cubic centimeters. The concentration fluctuates slightly with the severity of the burn and decreases as the burn wound heals. The concentration of fibrinogen and thrombin approximates that in the plasma as does that of all the freely diffusible substances such as the non-protein nitrogen, carbohydrates and electrolytes.

Coagulation of the edema fluid of the wound is negligible; this is verified by the prolonged weeping from a bleb with a broken roof. With the rise in edema and interstitial fluid pressure there is an increased return of the capillary filtrate through the lymphatic trunks to the blood stream. As fluid continues to pour out of the capillaries there is a slow flushing of the wound.

The retarded coagulation of the fluid of the burn wound permits free interchange of diffusible substances. Sulfonamides injected intravenously permeate the wound and those applied on an open area are rapidly absorbed.

The nature of the burn wound may be altered by infection and the superimposed infectious inflammation. As long as the corium of the skin is intact, even though killed by heat and lifted off the dermis as the roof of a bleb, organisms have difficulty in penetrating into the wound. Virulent organisms are usually not found in the fluid of unruptured blebs. When the corium is broken either by the rupturing of a bleb or cracking by the heat, bacteria infiltrate the wound.

## GENERAL CONSEQUENCES OF LOCAL CHANGES

**Shock**—The generalized vasomotor collapse or primary shock, presumably of neurogenic origin associated with pain and excitement, is instantaneous, transitory and of little clinical importance. The shock which must be respected is that due to a diminishing circulating plasma volume which is caused by continuous seepage of plasma out through the damaged capillaries. As the plasma volume is reduced without concomitant loss of red blood cells, the hematocrit or red cell concentration and the viscosity of the blood rise. The blood flow is impeded, the cardiac output is curtailed, the blood pressure falls and there is an inadequate circulation to the unburned organs and tissues as well as to the wound. In an extensively burned patient, advanced shock is present within an hour.

Because of its dilated arteriolar bed, the wound is a parasite upon the failing circulation and steals blood from the vital organs. The circulation to the brain may be maintained until the last, but the kidney, liver, intestinal tract and muscles may be sentenced to live under anoxic conditions. Circulation in the kidney may be so retarded that renal function is almost or entirely stopped. Excretory products accumulate. If the renal blood flow is cut off for a few hours, the kidney cells may be so injured that they never recover, and even if the general circulation is restored, death in uremia follows some days later. Functions of the liver such as deamination and glycogen synthesis are eliminated in the absence of adequate oxygen. The products of anaerobic muscle metabolism differ from the aerobic; the concentration of organic acids such as lactic and pyruvic acid rises and produces a generalized acidosis. The intestinal tract cannot serve anaerobically and it regurgitates fluid and food taken into the stomach. With the ensuing dehydration there are electrolyte changes as the result of a shift of intracellular water.

**Infection**—Infection prospers if organisms gain entrance to the burn wound. Not only are the viable cells killed and wound healing retarded, but shock and malnutrition are fostered. Shock and infectionabet each other for if some degree of circulatory

failure is present many of the virulent organisms including strains of the streptococcus proliferate more rapidly under the partial anaerobic conditions. Malnutrition and anemia from red cell destruction may hobble the recovery of the deeply burned infected patient. Infection engenders fever and is the only known source of toxemia in burns.

**Elimination of Abnormal Protein**—Massive hemolysis, hemoglobinuria and albuminuria may be observed in severely burned patients within the first few days. The red cells are broken and rendered fragile by the intense heat. The source of the albumin in the urine is not established; it is believed that cell and plasma proteins are denatured by the heat and infection and when absorbed from the wound have to be excreted if not metabolized. If an adequate plasma volume and blood flow to the kidney is maintained, such albuminuria and hemolysis leave no permanent damage.

**Alarm Reaction**—The general physiologic response to trauma has been termed the alarm reaction by Selye. Burns as well as fractures and muscle trauma initiate a metabolic and glandular reorientation in which a rapid loss of non-protein nitrogen through the kidney overshadows other metabolic changes. The adrenal cortex is summoned to overactivity; this is demonstrated by an immediate rise in 17-ketosteroid excretion to a level above normal for a week. The metabolic disturbance may last until the wounds are healed and may be modified by an intercurrent infection and surgical procedures which reinstitute the acute phase of the alarm reaction.

### TREATMENT

The treatment of burns consists of the preservation of life, prevention of complications and the expeditious healing of the wound. The measures to apply are considered separately for the sake of clarity, but they must be synchronized and the plan depends upon the exigencies.

**Primary Surface Treatment**—The treatment of the surface is reviewed first because it should be initiated the moment the patient is burned, not because it is the immediate life-saving measure.

At the moment the burn occurs the wound is essentially sterile. Contamination of this

wound should be discouraged by protecting it immediately with a sterile dressing. If this dressing is applied by a physician competent to judge the extent and depth of the burn, it constitutes the *primary surface treatment*, both first and definitive. If the initial treatment is carried out by a lay individual in the absence of the responsible physician, it is called *first aid treatment*, even though it is identical to that which would have been applied by the physician. Following the first aid treatment, the responsible physician will need to revise the dressing to determine the extent and nature of the wound, and this is called *definitive treatment*.

Before the dressings are applied, the physician should be sure that an accurate chart of the extent and depth of the burns can be reconstructed. This is indispensable for the treatment of shock and subsequent care of the surface wounds.

There is no known substance which expedites healing of a wound beyond the rate obtained under normal physiologic conditions and in the absence of infection. The substance to be applied locally to a burn wound is one known to be non-injurious to tissues and an effective barrier to the invasion of bacteria. Gauze, petrolatum, carbowax ointments and petroleum greases and oils are such substances. All of these can be sterilized. Petrolatum and gauze used in combination is the treatment of choice. Grease has the additional qualification of being soothing. Automotive greases or oil may be used if petrolatum is not available. Since they do not conform to pharmacopoeial standards, they are used only in emergencies. However, a compromise surface dressing if immediately applied is better than accepting bacterial contamination by awaiting a better one. The disadvantage of the carbowax ointments is that they are absorbed and leave an adherent uncomfortable dressing.

Tannic acid, gentian violet and the tripl dyes are known to be injurious to cells and are not recommended. Tannic acid is toxic and when absorbed causes liver damage.

Boric acid and various sulfonamides which can be incorporated in ointment bases are not injurious to cells except in high concentrations. However, they are absorbed

from the wound and their internal toxicity eliminates their use. Ointments containing either may be applied to burns of small extent. Since they should not be applied to extensive burns it is wise to exclude them.

Pressure bandages should be applied over the dressings of wounds of the face, scalp and extremities in order to diminish the volume of edema and immobilize the wound. By checking the edema less plasma is lost from the blood stream. Immobilization aids the body in localizing the infection. The pressure must be carefully applied in order to avoid a tourniquet effect. On the extremities it should always start at the toes or fingers and diminish proximally. Elastic bandages over thick, fluffy graze or mechanical waste achieve even pressure. Rolled newspapers may be incorporated as splints. The extremities should be fixed in the position of function. The dressings of the head and scalp may incorporate the chin but not the neck. Plaster bandages are the ultimate in pressure but to be effective must be applied immediately after the burn before any edema has collected. They are useful only for the extremities; even then application is difficult over fingers and toes and a tourniquet effect is easily produced. The lack of time and personnel precludes their use in a catastrophe.

The primary dressing is applied with no cleansing or debriding of the wounds. If the wounds have been grossly contaminated with manure or dirt they should be generously irrigated with running water. It is impossible to rid a wound of all bacteria without excising it or applying corrosive chemicals. The debridement of superficial burns which consists of removing epidermis that over intact blebs or that rolled up in the corners of ruptured blebs only violates the protective barrier and serves no purpose. It is a relic of the tannic acid method. Debridement of deep burns is a major operative procedure and must be postponed until shock has been combated and the patient is ready for skin grafting.

A primary dressing of petrolatum gauze and pressure is suitable for burn wounds, no matter what the circumstances. It is so simple to apply that in a disaster where there is a disproportion of casualties to trained medical personnel the latter can be

freed for the more complicated care of shock. It is to be used for deep as well as superficial burns. It is suitable for all parts of the body including the eyes. It is to be left in place until shock has been averted or controlled and nutrition is satisfactory. For burns of first and superficial second degree it should constitute the permanent dressing and should not be changed for two weeks or until such time that it is judged the wounds will be healed. In deep second degree and full thickness burns the primary dressing serves until the patient's condition warrants consideration of grafting procedures.

**Subsequent Surface Treatment of Full Thickness Burns**—All full thickness burns of more than minute extent require grafting. The sooner the wound is closed the less will be the infection, malnutrition and scarring and the shorter the hospitalization. Burns of limited extent and undoubted full thickness should be grafted within the first few hours since shock will not be present to preclude an operative procedure. Also bacterial organisms will not have had time to invade the viable tissue. A burn of limited extent of certain deep second degree but of debatable full thickness depth should also be grafted immediately in order to shorten the convalescence of the patient and intercept scarring and contractures.

The grafting of extensive burns should be delayed until shock and infection have been averted or controlled. In the first thirty-six hours during the phase of plasma loss an operative procedure is hazardous. If the blood volume has been amply maintained operation is prudent any time thereafter. On the other hand the longer the delay in grafting the greater will be the infection which in turn diminishes the blood volume, increases the operative risk and makes less likely the take of the graft. Probably only a limited area of the surface, not more than 10 per cent, should be grafted at any one operation. It must be realized that the wound surface is being increased temporarily each time skin is cut for a graft. Although the burn wound is closed by the graft the patient does not benefit within the first forty-eight hours.

Lack of unburned skin to be used for grafting and malnutrition of the patient as

well as shock and infection may also demand postponement of grafting

When the primary dressing has been removed for evaluation of the wounds and it is judged that grafting cannot be undertaken a dressing similar to the primary one is applied

Before a burn wound can be grafted it has to be free of slough for slough precludes proper nutrition of the graft and harbors bacteria. Spontaneous debridement of slough requires three weeks or longer and inevitably leaves a granulating base. Granulating fibrous tissue leads to scarring and contractures. If infection is rampant in the granulations further delay of grafting is occasioned until infection is controlled.

Debridement can be expedited by either surgical excision or dissolution by pyruvic acid dressings. For burns of limited extent which are to be grafted immediately surgical excision is the only method since the action of the acid requires a minimum of forty eight hours. An extensive burn may be debrided either by excision or dissolution.

Debridement by surgical excision has the advantage of removing completely not only the necrotic tissue but also any inflammatory barrier that may be present. The graft is laid upon freshly exposed tissue not a granulating surface and eventual scarring and contracture are diminished. The disadvantage is that in the process of excision blood is lost and the operative time prolonged.

The disadvantages of the removal by pyruvic acid are as follows. It is not effective short of forty eight hours; it is uncomfortable and progressive contamination is courted by the multiple dressings required. Its advantages are that blood is not lost during the debridement and since it is accomplished separately from the grafting procedure the operative time is not lengthened.

The area debrided by either method may be larger than can be grafted at one operation either because of lack of skin or because of the excessive operative time. The longer the interval between debriding and closure the more granulation tissue will have formed and the greater will be the scarring.

Split thickness skin grafts are to be used

in the initial grafting of full thickness burns, the thinner they are the greater the chance of survival. Excised by means of the Padgett dermatome they are best used as intact sheets and whenever possible the debrided surface is covered in its entirety. If the available skin is smaller than the site to be grafted the skin can be economically used by cutting the sheets into pieces the size of a postage stamp. These pieces are spaced as islands from edges of which the epithelium grows out to close the wound.

The grafts should be immobilized with a firm bandage and the extremities splinted.

Excessive scar formation due to infection and profuse growth of granulations before grafting may result in unsightly wounds or limiting contractures. Secondary surgical excision of the scar and grafting are indicated after all signs of active inflammation have disappeared. Thick split thickness grafts and occasionally full thickness grafts will be required.

**Shock**—The first complication of a burn to threaten survival of the patient is shock. The two types primary and secondary are of different etiology. Primary shock is independent of the extent of the burn and revolves around the circumstances of the accident.

*Primary shock* or *vasomotor collapse* is induced by excitement and pain. It rarely endangers life and responds to the prone or head down position, reassurance and the appropriate drugs. The alarm which sometimes amounts to mania may be due to hysteria or to anoxia. *Morphine* is the drug of choice for the treatment of pain. Large doses are not often required since the pain is usually not excruciating or prolonged. The pain of burned hands may be relieved by elevation. If mania is present care must be taken to see whether it is due to pain, hysteria or anoxia. If it is due to hysteria *barbiturates* should be given; if due to anoxia *oxygen* alone will give relief and both the depressants morphine and barbiturates are to be avoided.

*Secondary shock*, the result of loss of circulating plasma volume is the vicious shock and is proportionate to the extent of the burn no matter what the degree. The volume of plasma filtrate lost into a burn wound and the rapidity of its loss are so



great that measures must be taken promptly if the patient is burned over more than 10 per cent of the body surface. If 20 per cent of the body surface is burned a volume as large as the normal plasma volume may be lost into the wound in the space of eight hours.

The ideal treatment of secondary shock is its prevention for it is more effective and economical to prevent rather than to correct it once established. The principles of treatment are the same whether used in prevention or in the presence of shock and consist in the maintenance of normal nutritional environment for the unburned organs and tissues. The wound is a parasite and treatment consists of giving to the body what the wound steals from it. Since plasma loss starts immediately after the burn prevention demands instantaneous institution of therapy. For each per cent of the body surface burned 75 cc of plasma should be injected intravenously for the first twenty-four hours. Since the rate of edema formation decreases with time half of the total amount should be injected within the first eight hours. An equal volume of electrolyte solution should be given simultaneously, preferably by mouth. Isotonic sodium chloride solution may be used but an isotonic solution made up of two-thirds sodium chloride and one-third sodium bicarbonate is better since the excess of chloride is avoided. An additional 2,000 cc of fluid not containing salt is given in the first twenty-four hours in order to maintain kidney function. If the patient vomits both electrolyte solution and water as a 5 per cent glucose solution should be given intravenously. It is however more economical to give these fluids by mouth since the plasma flows more rapidly into the wound if it is diluted. If the patient is thirsty or if kidney function ceases an inadequate amount of plasma and electrolyte solution is being given. Repeated hematocrit or hemoglobin readings should be made and if hemoconcentration is present the rate of injection of the plasma is to be increased. In order to judge the adequacy of kidney function an indwelling catheter should be employed for all severely burned patients for the first thirty-six hours.

In the second twenty-four hours half of the amount of plasma and electrolyte solu-

tion required in the first twenty-four hours should be given. The peak of edema is reached usually between thirty-six and forty-eight hours. After forty-eight hours plasma and electrolyte solution are required only if inadequate amounts have been given in the previous two days. Indeed if therapy has been adequate further plasma and electrolyte are contraindicated because after forty-eight hours the resorption of edema fluid is usually under way. The flow of protein electrolytes and water from the wound into the blood stream is greater than the loss and the body is now faced with eliminating or metabolizing the electrolytes and plasma originally given as therapy. The administration of large volumes of fluid after forty-eight hours may therefore result in overhydration and pulmonary edema. During the period of edema resorption only enough water should be given to maintain an adequate kidney function. 2,000 cc a day is usually adequate.

If an extensively burned patient is not treated within two hours shock will have occurred. This is particularly true in children. For an adult the volumes of plasma and electrolyte solution are administered according to the formula of Harkins: 100 cc for each per cent that the hematocrit reading is above 45. This amount should be given as rapidly as possible and repeated until normal hemoconcentration has been achieved. Subsequent amounts of plasma to be given are calculated on the basis of the surface area formula. When the extremities are burned both the femoral and the external jugular veins may be used. The saline and water for kidney function may be given by mouth if possible as in the prevention of shock.

In patients who have been in prolonged shock acidosis may exist. In these cases it is particularly important to give one-third of the electrolyte solution as sodium bicarbonate.

If plasma is not available there are the following substitutes here given in the order of preference: whole blood, albumin concentrate and gelatin. An extra amount of electrolyte should be given if the albumin concentrate is used. If none of these is available the amount of electrolyte solution is doubled, half is given intravenously with

glucose added. Such non colloid therapy results in extracellular fluid protein dilution but this dilution is preferable to the hemoconcentration of no therapy.

Patients with burns of less than 10 per cent of the body surface may not require treatment to prevent shock if adequate water is administered. There will be a slight overall plasma protein and electrolyte dilution but if the patient was healthy before the burn the body is well able to compensate.

If pulmonary damage is present it may be wise to allow a moderate degree of hemoconcentration to persist in the hope of avoiding pulmonary edema and respiratory death. Whole blood should be given in place of part of the plasma. Tracheotomy is indicated when there is obstruction of the larynx.

Use of adrenal cortical extract in burn shock therapy is not established even though there is evidence of disturbance of adrenal cortical function.

**Infection.**—Having survived shock the burned patient faces infection for all burn wounds except those of first degree are potentially infected. The second degree superficial wound becomes infected only when the epidermis over the blebs ruptures and the organisms on the surface can penetrate it. In the deep second and third degree burns where the epidermis is cracked infection is to be anticipated. As in the treatment of shock prophylaxis is easier than eradication. Prophylactic chemotherapy is indicated except for minor second degree burns. Infection develops rapidly and may be present within six hours.

*Penicillin* is the most effective drug yet available for prophylaxis and treatment. It acts against most of the gram positive organisms and when given intravenously or intramuscularly it prevents invasion of the unburned tissue. Given parenterally it is not able to control the growth of organisms in the slough of deep burns. Its instability limits its local use to wounds which can be irrigated at frequent intervals. For a 10 per cent burn 100,000 Oxford units should be given parenterally per day in divided doses. For burns of greater extent amounts up to 400,000 units per day may be given. For prophylaxis the drug should be started

immediately. In the deep burns of limited extent which are treated with immediate debridement and grafting prophylactic chemotherapy is optional.

Subsequent chemotherapy will depend upon the depth and extent of the burn. For the superficial burn nothing more than prophylactic penicillin will be needed. In the deep burns infection will remain until the wounds are debrided and grafted and chemotherapy should be continued until they are healed. The dosage of penicillin and the agents to be used in addition will depend upon the nature and virulence of the infection. Swab cultures should be taken before the primary dressing is applied and at subsequent change of dressings. The results will guide the use of chemotherapy. Heavy infestation of gram positive organisms especially streptococci and staphylococci demands an increased dosage of penicillin both parenterally and locally. *Gramicidin* is useful locally; it is more stable than penicillin. The presence of gram negative organisms may indicate the use of *Dalacin* solution.

One of the *sulfonamides* may be used if penicillin is not available. The sulfonamides control only the streptococci as effectively as does penicillin. They are toxic in contrast to penicillin. Their local use must be carefully limited in order to avoid absorption to toxic levels.

**Malnutrition.**—The malnutrition of burns—wasting and anemia—may be abrupt in onset and extensive. To the local destruction of cells and protein by the heat and subsequent infection is added the general breakdown of reserves by the alarm reaction and infectious toxemia. Malnutrition will not be a problem in a patient with a burn of less than 10 per cent of the body surface unless the wound is severely infected. In an extensively burned patient malnutrition may be severe enough to retard the regeneration of cells and the healing.

The nutritional deficit created by the local destruction of tissue and blood is probably a minor problem. More important are the general disturbances incurred by fever, alarm reaction and infectious toxemia.

Burned patients have fever proportionate to the extent of their wounds. With a fever

there is elevation of the metabolic rate and an increased demand therefore for combustible materials including carbohydrate and fat. The main deficiency developing in a burned patient however appears to be that of protein and is engendered by the alarm reaction. As much as 40 Gm of non-protein nitrogen the equivalent of 252 Gm of protein may be excreted through the kidney daily. Muscle atrophy accompanies such loss.

The caloric and nitrogen deficits are best met by dietary measures. By the use of milk milk products eggs meat chicken and fish an enticing high protein and high caloric diet can be arranged. An intake of 200 Gm of protein and 4000 calories should be striven for and should be started immediately. If the patient is nursed stomach tube feedings including protein digests should be resorted to. Amino acid mixtures may be given intravenously in addition to plasma and whole blood transfusions. A liberal quantity of vitamins particularly vitamin C and the B complex should be included in the diet.

Red blood cell destruction presumably the result of infectious toxemia is a prominent feature in patients with deep burns in the first three weeks. It cannot be controlled by the dietary intake of protein and iron. The reticulocyte count is not depressed but does not rise above normal until the hemolytic phase is passed. Replacement of red blood cells can therefore be achieved only by transfusion of red blood cells or of whole blood. From the fifth to the fifteenth day when the hemolytic phase is at its height patients have required on the average as much as 600 cc of whole blood per day to maintain a normal circulating volume of red blood cells.

OLIVER COFF

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INJURIES DUE TO COLD

The feet hands nose ears and cheeks are the parts of the body most frequently damaged by cold partly because of their exposed position and their large surface area as compared with the total volume and partly because of anoxia from vasoconstriction secondary to chilling of the skin. Injury may result directly from actual freezing of the tissues (ordinary and high altitude frostbite) or may be secondary to changes in the blood vessels brought on by long exposure to cold without actual freezing (immersion hand or foot). Certain patients with neuroses may complain of subjective symptoms but no objective changes are demonstrable.

Actual freezing which may occur in a healthy person in a cold climate is seen in temperate climates only when a debilitated or comatose person is long exposed to a freezing temperature. However in high altitude flying individuals in any climate may be transported quickly to an extreme degree of cold and may at times have to expose themselves. With any frostbite there is little pain until thawing begins then as a result of the extravasation of fluid and an inflammatory reaction the pain is excruciating. This is followed by anesthesia if the part is dead and by paresthesia or hyperesthesia if the tissues survive.

Where there is long continued local loss of heat with impairment of circulation but without actual freezing there is an initial vasoconstriction followed by vasodilatation during which the part becomes pink or red.

Following this there is progressive swelling with increasing impairment of the circulation. Even after the exposure is over thrombosis may occur and cause extension of the damage. The damage either from actual freezing or from long exposure without freezing may be superficial with only redness and swelling either with or without the formation of blisters or deep with either moist or dry gangrene of the skin and any amount of the subcutaneous tissues.

In certain persons with poor circulation and low resistance chilblains may develop

situ for exposure which within a time of seconds or minutes may freeze fingers solid. Also suitable equipment for shipwrecked persons might reduce the incidence of immersion damage to feet and hands.

After an injury due to cold has been sustained general systemic as well as local treatment should be given. The patient should be kept in a relatively cold room and hot drinks and stimulants given as indicated. The temperature of the part should be gradually raised by placing it in contact with the body of a healthy person. Some



Fig. 17.—Fistula of the hand. Appearance six months after exposure followed by sloughing of the palmar fat pads. The fingers are smooth and glazed in appearance, the joints are stiff and painful on motion and the growth of the nails has been retarded.\*

as a result of repeated exposure to cold with little muscular exercise. There is itching of the involved part and a chronic erythema develops. The skin is roughened and ulceration may result. If infection occurs the damage may be extensive.

**Treatment.**—Prophylaxis is most important and consists in avoiding long exposure to cold and dampness, particularly if the body is in poor condition or without adequate protection. Gloves and shoes should give proper insulation and should never be tight fitting.

In high altitude flying proper engineering may go far toward avoiding the neces-

sity of keeping the part at a temperature only slightly above freezing for several days, but this has not been accepted generally. If other methods of raising the temperature are tried every precaution must be taken to avoid overheating, since the impaired circulation cannot dissipate the heat. Care should be taken not to break the skin, hence the part must not be rubbed with snow or a wet cloth. After the temperature has been restored the part should be cleaned and wrapped in sterile cotton, then elevated in order to favor venous and lymph

\* Lew. Practice of Surgery. W. F. Prior Co. Publishers.

phatic drainage and the patient moved to a warmer room.

Much consideration is being given to producing vasodilatation by various methods: (1) application of heat to the body as a whole (2) giving drugs which have a direct effect on the musculature of the blood vessels or (3) drugs which affect the autonomic nervous system and (4) blocking the sympathetic nerve trunks or peripheral nerves. According to Davis and others the drugs which could be taken early without the aid of a doctor have been a total failure. The desirability of sympathetic block is still open to debate and must be decided on its merits for each case. Passive vascular exercises have been advocated to improve the circulation.

The subsequent treatment consists in avoiding pressure or overheating and varies according to the extent of the injury. If the skin is intact active and passive motion and massage may favor the return of circulation and help maintain function. When the skin is broken infection should be guarded against by painting the area with gentian violet and covering it with dry sterile dressings. If infection occurs it should be combated by means of hot wet dressings and by removal of dead tissue incision and drainage or by amputation. If gangrene appears the part should be put at rest under aseptic conditions and separation of the dead tissues awaited. It must be remembered that the gangrene may be superficial (Fig. 17) that it is usually less extensive than it appears and that even when deep the defect can at times be repaired by skin grafting. If the entire part is gangrenous amputation is necessary.

DEMYL HART

## INJURIES DUE TO CHEMICALS

Injuries due to drugs and chemicals are numerous some resulting from drugs taken internally others from substances (too numerous to tabulate) applied locally which cause dermatitis of varying degrees of severity. These forms of dermatitis are treated by removal or discontinuance of the causative agent. No attempt will be made to discuss them here but for further information the student is referred to books

on dermatology or industrial medicine. The present discussion will be limited to the more severe injuries caused by acids and alkalis phosphorus magnesium and the war gases mustard and lewisite.

The diagnosis of a chemical burn in industrial or civilian practice usually presents no problem since each patient is familiar with the nature of the chemical to which he has been exposed.

**Acids and Alkalis**—Acids and alkalis in normal times cause the majority of chemical burns and are best treated by immediate washing and dilution of the agent with water. Large quantities of water should be applied as quickly and rapidly as possible since this not only removes the acid or alkali in the quickest possible way but also dissipates the heat generated by the mixtures of the water with the acid before it can damage the exposed tissues. This is the most important part of the treatment\* but may be followed by neutralization with an appropriate chemical agent such as dilute acetic acid or dilute solution of sodium bicarbonate. If a neutralizing agent is employed care should be taken to avoid using it in such strength as to cause further injury to the already potentially damaged tissues. This is particularly true of the eye. After as much as possible of the acid or alkali has been removed with or without neutralization the wound should be treated as any other burn.

An exception to the immediate washing off of alkali with water should be made in the case of dry powders such as lime. These should be brushed off as completely as possible before washing.

**Carbolic acid** in concentrated form causes rapid coagulation of superficial tissues. Like other strong acids it causes a sharp pain which usually prompts its removal or neutralization. When the acid is not removed the damage is superficial since the coagulated tissues prevent deep penetration.

Carbolic acid in weaker solutions is more dangerous than the concentrated form. It is soluble to about 5 per cent in water and is seldom applied in greater strength but evaporation of water may cause its strength to increase rapidly. When first applied it may cause slight pain but soon the stage of anesthesia begins and there is no danger

signal to warn the patient of the insidious penetration. It is most dangerous when applied as an occlusive wet dressing to a small part for instance a finger. It penetrates deeply albumin is coagulated blood vessels become thrombosed nerves are made anesthetic and the part becomes cold and numb. The area is first blanched blisters may then form and finally depending on the absence or presence of infection dry or moist gangrene develops. Moist dressings of a solution of from 1 to 5 per cent applied for from five to twenty four hours have repeatedly caused gangrene. It must be kept in mind that the salves and ointments are as dangerous as the solution.

Carbolic acid should be suspected as a causative agent whenever gangrene develops in an area which is being treated with a solution or ointment of unknown nature.

Carbolic acid should be neutralized or diluted and removed by application of ethyl alcohol. The resulting wound should be treated so as to avoid or control infection and facilitate healing. Deformity should be prevented and healing may be hastened by the judicious use of skin grafts.

**Phosphorus Burns**—Phosphorus burn should be treated by immediate immersion of the part in water or if this is not possible the burned area should be kept covered with wet compresses since water prevents burning of the phosphorus. Particles of phosphorus should be removed preferably with the part still under water using gauze covered forceps. The area then should be washed with a dilute alkaline solution followed by 1 per cent copper sulfate solution to give a protective coating of copper phosphide to any residual particles of phosphorus. These dark particles should then be removed. After all phosphorus has been removed the resultant wound should be treated as an ordinary burn. The search for small particles of phosphorus may be made in a dark room under which condition the natural fluorescence simplifies its location.

An exception to the application of water to phosphorus should be made in the case of the pentoxide pentosulfide and pentochloride powders. These should be carefully brushed off before washing since when they are mixed with water much heat is generated and phosphoric acid is produced. If

water is already present (e.g. perspiration) the part should be flushed with large quantities of water as rapidly as possible to dissipate the heat and remove the acid.

**Magnesium Burns**—Magnesium burns are usually small and produce a gradually enlarging ulcer if all the metal is not removed. No neutralizing agent is available. After an aseptic preparation of the skin and injection of a local anesthetic the burned ulcer should be curetted out down to healthy tissue. Following this the course and treatment are similar to those for non specific ulcer from any other cause.

**War Gases**—The war gases most commonly causing skin injuries are mustard gas and lewisite.

**Mustard gas** is a skin irritant and produces blisters with deep destruction of the skin. Contaminated clothing should be removed immediately. The liquid must be removed from the skin as soon as possible by dabbing with dry pads and never by rubbing since this spreads the liquid. Pads should be used only once to avoid spreading the liquid to uncontaminated areas.

The remaining mustard liquid or gas should then be removed or neutralized by one of the following methods: (1) dabbing with dichloramine-T in triacetin (2) removal with solvents such as gasoline kerosene carbon tetrachloride or alcohol with precautions as to spreading the irritant and the avoidance of hazards of fire (3) application of products containing active chlorine such as grade A calcium hypochlorite or sodium hypochlorite (Dakin's solution). The calcium hypochlorite may be mixed with 1 to 2 parts of water to form a paste but since this is irritating it should be washed off within three minutes. If no other neutralizing or solvent agents are available liberal use of soap and water gives very satisfactory results.

After the mustard has been neutralized the skin should be washed with soap and water and patted dry. Burns should be treated as other burns with suitable precautions to avoid or control infection and facilitate healing.

The hair must be decontaminated or clipped. The eyes should be irrigated immediately for ten minutes with 2 per cent sodium bicarbonate solution saline or plain

water, but only if within five minutes of contamination. Further treatment of the eyes should be carried out by an experienced ophthalmologist.

**Lewisite,**<sup>4</sup> a skin irritant containing arsenic, penetrates rapidly, so that prophylactic treatment of the skin should be begun within one minute after exposure. Contaminated clothing and the lewisite should be removed with the same precautions as for mustard gas. The neutralizing agents for lewisite are different, and one of the following may be used: 1. Light per cent hydrogen peroxide is the best, but the 3 per cent solution may be used. Fresh swabs should be employed for each application, with precautions to avoid spreading the irritant. 2. Sodium hydroxide as a 10 per cent

treatment is available, the burned skin may be excised to save the patient's life by removing the arsenic. After the irritant has been eliminated the burn should be treated as for a mustard gas burn.

**Dermatitis factitia.**—*Dermatitis artefacta* should be specifically mentioned here, since these lesions are frequently caused by chemicals (carbolic and other acids, alkalis, creosol, croton oil, mercuric chloride, cantharides, etc.) as well as by rubbing and other forms of trauma. The history is of course unreliable, since the patient is making every effort to deceive his family and his doctor as well. The lesions are usually few in number, they frequently appear at night and they are more commonly located on easily

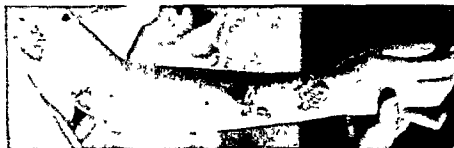


Fig. 18.—Large self-inflicted eschars probably caused by application of sodium hydroxide to which the patient had access. All lesions healed while the patient was in the hospital but others appeared two months after discharge.\*

solution in 30 per cent glycerin may be used if hydrogen peroxide cannot be obtained. The skin should be swabbed with this agent, alternating with alcohol. If glycerin and alcohol are not available a 5 per cent aqueous sodium hydroxide may be used, alternating with water instead of alcohol. 3. In the absence of neutralizing reagents, the same solvents used for mustard gas (e.g., gasoline, kerosene, carbon tetrachloride or alcohol) may be used in the same manner and with the same precautions as for mustard gas. Lewisite like mustard gas can be rather effectively removed with the liberal use of soap and water.

After the agent has been neutralized or removed by a solvent, the skin should be washed with soap and water.

The blister fluid contains arsenic, and this may be evacuated to limit absorption and must not be allowed to contaminate the skin, since it is irritating. When no other

accessible parts of the body (Fig. 18). As the older lesions heal, new ones appear until the diagnosis is made or until the patient has accomplished, or failed to accomplish the purpose for which the lesions were inflicted (i.e., obtaining sympathy, avoidance of unpleasant duties, sexual gratification, etc.).

The nature of the lesion may be suspected from its artificial appearance, the absence of anything to account for its occurrence and the general reaction of the patient. Such patients stress their suffering and ill health, plead for something to be done and in general give the appearance of being overcooperative.

The diagnosis might be made by keeping the patient under secret observation. Confirmatory evidence can be easily obtained by covering the part with a fixed dressing such as a plaster cast, following which, all

\* Hart. Tr. North Carolina M. Soc.

wounds heal and no new lesions develop in the protected area. The patient should not be openly accused until there is conclusive proof that he is responsible for the wounds. Even then the doctor can often let the patient know that the correct diagnosis has been made but need not actually accuse him.

*Treatment* may offer many difficulties and frequently causes the patient to go to another doctor. Healing can be obtained by covering the part with a protective dressing. In many cases after the patient realizes that the doctor knows the nature of the trouble he will discontinue inflicting the injuries. Certain patients however go from doctor to doctor and their treatment constitutes a major psychiatric problem.

DERYL HART

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#### ELECTRIC SHOCK

**Etiology**—The effect of electric current on an organism depends on (1) voltage (2) amperage (3) type of current (4) resistance and (5) individual susceptibility. Deaths have been reported as resulting from 46 volts. With currents alternating at from 25 to 300 cycles voltages under 250 tend to produce pure ventricular fibrillation, those over 1000 pure respiratory center paralysis and those between 220 and 1000 affect both the heart and the respiratory center. Contrary to the general impression high voltage currents are less dangerous than low voltage currents.

The amperage ( $\frac{\text{voltage}}{\text{resistance}}$ ) is difficult to determine because of the variable resistance of the body. High amperage is usually less dangerous than low. Alternating currents of from 70 to 110 ma or a direct current of from 200 to 250 ma may be fatal if passed

through the chest. Alternating current is three to five times more dangerous than direct. Those from 39 to 150 cycles are the most fatal. As the number of cycles increases the danger diminishes. Spark discharges can be fatal by paralyzing the respiratory center. They can produce ventricular fibrillation only if the heart is struck during the vulnerable period of late systole. The resistance of the body depends to a great extent on that of the skin. Except for bone all other tissues have comparatively low resistances. The dry skin averages about 5000 ohms and when wet 1000 ohms so that a current of 100 volts (100 ma) could be fatal. With saline electrodes it may fall to 300 ohms so that a current of only 30 volts (100 ma) may cause death if passed through the chest. In a calloused palm the resistance may reach 1 000 000 ohms. Perspiration reduces resistance. Shoes shod with iron nails or moist shoes make good contact with the ground and allow a current to pass through the body. A broad surface and firm contact permit the flow of more current than smaller and lighter ones. The passage of the current through a conductor generates heat in direct proportion to the resistance producing local marks and burns.

Electric marks or contact burns are not ordinary burns. They are usually round or oval from a few millimeters to several centimeters in diameter gray to gray yellow and sharply demarcated from the normal tissue. The hairs are not affected. The lesions are odorless painless and free from inflammatory reaction or blisters. They remain unchanged for several weeks after which occurs a slow process of aseptic necrosis and sloughing with the eventual formation of a smooth pink scar. The resultant slough is often two or three times the extent of the original lesion probably because of the disintegration of the media of arteries often far distant from the original lesion. These marks are considered the most characteristic manifestations of the passage of electricity through the body. With light or brushing contacts flash or arc burns are produced. These have a temperature ranging from 2500° to 3000° C and may produce extensive lesions involving entire extremities. Metallic deposits are often found around and embedded in the burned area.



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The final slough is usually much more extensive than the original burn. Secondary hemorrhage is common. As a rule if the resistance is low the general effects are severe and burns slight; if high the burns are severe and the general effects slight.

**Pathologic Physiology**—Death from electricity may occur as the result of (1) primary fibrillation of the ventricles (2) failure of the respiratory center (3) ventricular fibrillation plus respiratory failure (4) prolonged tetanus of the respiratory muscles or (5) delayed death. When fibrillation occurs there are no heart sounds or pulse and the patient is unconscious; respirations continue, become exaggerated from asphyxia and fail in about two minutes, death ensuing. When the respiratory center alone is paralyzed unconsciousness occurs, respirations are absent but the heart continues to beat. There is a great fall in blood pressure and the skin is cold and cyanotic. When both the heart and the respiration are affected death occurs immediately. Some hold that in the majority of cases death from electric shock occurs as the result of uncomplicated ventricular fibrillation and that this state once established is usually permanent. Others maintain that in most cases death from electric shock is only apparent, that the victims suffer from temporary paralysis of the respiratory center and that if artificial respiration is continued until the center recovers, most of the victims will live. One case has been reported in which the patient was revived by artificial respiration after eight hours; several cases after four hours of suspended animation. In the writer's own series of fifty-eight cases 91 per cent of the victims died. Important data were available in only twenty-seven cases. Of these patients 52 per cent were unconscious, respirations were absent in 74 per cent. In all but two cases prompt pressure artificial respiration was immediately instituted and continued without interruption until recovery or until rigor mortis developed. In the fatal cases the duration of artificial respiration was four hours in one case, one and one-half hours. Eighty-two per cent of the patients died, 15 per cent as a result of falls or burns. Of the remainder 59 per cent probably died of persistent ventricular fibrillation.

**Pathology**—Postmortem studies regarding the nature of electric shock have been disappointing. Destruction of the media of arteries occurs frequently. When large currents are used as in legal electrocutions capillary hemorrhages are found in the cortex and in the floor of the fourth ventricle but these are not present in accidental electrocution from smaller currents. Pathologists do not agree as to whether certain minute changes occurring in the cells of the central nervous system are due to the current to postmortem alteration or to artefact. Transient albuminuria is frequent after electric shock. Casts and hemoglobinuria may be present. Edema of the lungs has been noted post mortem in over half of thirty-seven fatal accidents from low voltage. There are no pathologic findings that are absolutely indicative of the passage of an electric current through the human body.

**Treatment**—When an electric accident has occurred the victim should be freed immediately of the current. If he is at a height he may fall and sustain severe or fatal injuries. At times the current may hold him fast to the conductor. In any case the flow of current must be stopped immediately by throwing the proper switch or by severing the conductor using a properly insulated instrument or an axe with a dry wooden handle or by diverting the current by allowing a metal chain to make simultaneous contact with the conductor and the ground. The charged person may be dragged from the live line by means of dry clothing or a leather belt or pushed away with a stick of dry wood. If it is necessary to touch the victim the feet should be used, never the hands. When cutting the conductor, one should turn the head from the sight of contact in order to protect the eyes from the flash. If the victim is at a height preparations should be made if possible to prevent or lighten his fall.

The treatment of shock victims is usually undertaken by untrained co-workers who are unable to judge the nature of the electrical accident. Any victim who is not breathing should immediately be given artificial respiration and the latter continued without interruption until spontaneous respirations are resumed or death is certain. Jex Blake says that only the onset of rigor mortis or the

cooling of the body should be considered as evidence of death. The prone pressure method is best. Pressure and suction devices for maintaining artificial respiration may be dangerous and their use is not recommended. Lay co workers should treat all cases of unconsciousness as due to respiratory paralysis. The physician however is better qualified to determine the nature of the accident. If the victim is not breathing but there is evidence of regular cardiac action the prognosis is good and artificial respiration should be continued. If there is no evidence of cardiac function or respiration it is likely that ventricular fibrillation or cardiac arrest has occurred. If regular pulsations are noted in the neck the presence of fibrillation is more probable. A drop of ether instilled into one eye may reveal the presence of even a feeble circulation by the redness produced. The other eye serving as a control. A blunt probe introduced through the skin to lie against the ventricle may show whether the latter is normal fibrillating or quiescent. Precordial compression or the prick of a needle introduced into the heart may stimulate the arrested organ to contract normally aided if necessary by the injection of 1 cc of 1:1000 epinephrine. If this fails further attempts to institute normal rhythm whether for arrest or for fibrillation require immediate cardiac massage. A fibrillating heart is not a dead heart yet no amount of artificial respiration alone will bring back its normal beat. The cerebral circulation must be restored within fifteen minutes if the vital centers are to be viable and the cerebrum is to suffer no permanent deterioration. Thus unless the shock occurs in or near an operating room the chances for recovery from electrically induced ventricular fibrillation are practically nil. In favorable circumstances the heart is exposed quickly the condition of arrest or fibrillation determined and massage begun at once and continued until normal rhythm is resumed or death is certain. If the heart is quiescent massage alone may be successful if not success may follow the passage of a suitable electric current through the heart or the injection of epinephrine into the right heart followed by the current. If the ventricles are fibrillating the heart must first be brought to complete rest by passing the current

through it or by injecting 5 cc of 2 per cent procaine or 5 cc of 1 per cent calcium chloride into the right side followed by the current as advised by Beck. When defibrillated the heart is treated as if quiescent. Both epinephrine and calcium chloride tend to induce or maintain fibrillation. On the basis of dog experiments Wiggers although in essential agreement with the foregoing statements advises against the use of all drugs. If no facilities are at hand artificial respiration should be continued for twenty minutes in the hope that spontaneous recovery will take place. In cases of fibrillation long continued artificial respiration is illogical in cases of respiratory paralysis in which the heart is functioning artificial respiration is indispensable. In the majority of my cases electrically induced unconsciousness was due to ventricular fibrillation and artificial respiration was of little avail. This should not deter rescuers from carrying on prolonged artificial respiration when the diagnosis is in doubt.

The use of stimulating injections is not advised. Lobeline is dangerous and may even cause the death of the patient. Oxygen inhalations may act as a respiratory depressant. Carbogen (7 per cent carbon dioxide in oxygen) combined with artificial respiration is of definite value if the patient has begun to breathe. Subjecting the victim to a physical counter shock is unjustifiable. Prompt lumbar puncture and drainage should be done if signs of cerebral irritation or of increased intracranial pressure occur. The revived patient should be hospitalized and watched for sudden cardiac dilatation or secondary hemorrhage.

All electric burns should be treated with great care. Those which appear trivial at first may later become serious or fatal because of toxic absorption, secondary hemorrhage or infection. The local treatment is in accordance with the principles set forth in the section on burns. Shock should be treated promptly to bring the blood values to normal. Surgical treatment is not advised until the separation of sloughs because of the danger of alarming hemorrhage. Skin grafting may later be necessary. Amputations should be resorted to only after all conservative measures have been tried.

Repeated roentgenograms of contact sites

should be made because of the possible occurrence even months after the shock of osteoporosis followed by spontaneous fractures and sequestrum formation. There may be optic atrophy and retinal disturbances.

High cataract occasionally appears as late as two years. Marked disturbances of the central nervous system have been reported. Most commonly these are similar to ones which result from cerebral concussion and they may form the basis of litigation where workmen's compensation laws are in effect.

### TEXT I Pearl

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## INJURIES CAUSED BY IRRADIATION

**Definition**—The term radiodermatitis signifies an inflammation of the skin or orificial mucous membranes caused by exposure to x-rays or to radiation from the radioactive elements.

**Etiology**—Radiodermatitis results from the irradiation of tissue beyond the tolerance point.

**Pathology**—The first histologic evidence of acute radiodermatitis does not differ essentially from that of an ordinary inflammation. Thereafter the picture depends on the size of the dose administered and the radiosensitivity of the tissue. If the injury is beyond the possibility of immediate repair, there is degeneration of the epithelium of the skin and the cutaneous appendages of endothelial cells, collagen and elastic tissue. When the injury is very severe, necrosis and ulceration result. With the exception of mild injuries, repair is seldom complete. Degeneration leads to atrophy of the epidermis, sclerosis of collagen, marked changes in the elastica and a modification of function of or complete loss of the cutaneous appendages. In so-called x-ray or radium skin (chronic

radiodermatitis) almost every deviation from the histologic normal may be seen. The principal characteristics are atrophy of the epidermis with loss of papillae, badly degenerated atrophic or sclerotic dermis, clumping of degenerated elastic tissue, thin walled markedly dilated vessels, loss of appendages and necrosis. The epidermis may undergo hypertrophy at the edge of the ulcers and in other areas leading to keratoses and cancer.

**Symptomatology**—Radiodermatitis may be either acute (first, second or third degree) or chronic.

**First degree radiodermatitis** consists of erythema (redness) which usually appears about the fifth day, although it may be delayed several days or even a week or two. When the dose is sufficiently large it may appear within a day or two. When a second degree injury does not develop, the erythema endures for from one to three weeks and then slowly disappears either with or without temporary pigmentation. The hair is likely to fall out about the third week, the alopecia being either temporary or permanent. Subjective symptoms consist of a sensation of heat and perhaps some pruritus. A first degree radiodermatitis may be followed by such sequelae as atrophy and telangiectasia, keratoses and even cancer.

**Second degree radiodermatitis** in addition to more intense erythema is characterized by edema and exfoliation and perhaps superficial ulceration with or without crusting. During the acute stage there is a burning pain. Desquamation occurs during the third week and permanent alopecia results. Spontaneous healing occurs in from one to several months. Sequelae such as cicatrix, wrinkling, pigmentation, depigmentation and keratoses usually occur. Eventually cancer is likely to develop.

**Third Degree**—When the dose is sufficiently large the first and second degree radiodermatitis is followed by a third degree injury. This is characterized by severe inflammation, excruciating or unbearable burning pain and necrosis involving the true skin, perhaps the subcutaneous tissue and even the underlying muscles. The necrosis is usually of the dry type and lasts for many weeks or months. Eventually there is a slough which is gradually thrown off leaving

a deep indolent ulcer with abrupt margins and a glistening base. Depending on the size and depth of the injury, there may or may not be spontaneous recovery in the course of months or years. If not, the pain eventually disappears, and the indolent ulcer remains as a cancer menace. Even in the case of more or less complete spontaneous repair, the result is "x-ray or radium skin," which likewise is always a source of danger.

**Chronic Radiodermatitis.**—By this term is meant either the sequelae which result from acute injuries or those which result without an antecedent acute inflammation as a result of the administration of small doses over too long a period of time. The condition is commonly called "x-ray or radium skin." It may have one or all of the following objective signs and symptoms: telangiectasia, irregular pigmentation and depigmentation, atrophy, recurrent ulcerations, keratoses, indolent ulcer and cancer. Telangiectasia and atrophy develop, as a rule, within a year or two. Keratoses are more likely to appear several years later. Cancer may appear anywhere from a few to many years later. Subjective symptoms are either mild or absent.

**Diagnosis.**—As a rule, the diagnosis is easily made. In the case of acute radiodermatitis, there is the history of irradiation of the affected area followed by the sequence of events as outlined under symptomatology. Other inflammation, such as eczema, psoriasis, etc., may mask a mild radiodermatitis, but there is no entity that provides the same symptom complex or that will for long camouflage acute radiodermatitis. The same statements can be applied to chronic radiodermatitis, except that the latter may be confused, by the inexperienced, with conditions such as atrophic and keratotic eruptions caused by arsenic, xeroderma pigmentosum, and sailors' or farmers' skin. A first degree radiodermatitis must be differentiated from the "electric" erythema that sometimes occurs within a few hours after an x-ray exposure and endures for only a day or two.

**Prognosis.**—Because of the degenerative changes and sequelae that follow excessive irradiation, the tissues should never be exposed to amounts that exceed toleration, except when such treatment is specifically indicated and when the physician is justified

in administering very large doses as, for instance, in the case of serious or malignant conditions (cancer, certain of the lymphoblastomas, etc.). In about 25 per cent of the



Fig 19.—Third degree radiodermatitis of the back, eight months' duration. Slough has been thrown off leaving an indolent ulcer. Pain, which was unbearable for months, has lessened. Eventually a plastic operation was necessary.



Fig 20.—Chronic radiodermatitis duration of many years. The area shows many sequelae—atrophy, hyperplasia, pigmentation, depigmentation, telangiectasia, keratoses and, at the lower pole, ulceration and early carcinoma.

patients with cutaneous sequelae, cancer sooner or later develops.

**Treatment.**—Radiodermatitis of the first and second degrees requires no more than

soothing topical applications. Severe third degree radiodermatitis often necessitates surgical treatment. As soon as the necrosed area is well defined it should be excised. When all the badly injured tissue is removed pain ceases at once granulations appear and the wound if small cicatrizes. When the area is extensive skin grafts a sliding flap or a tubular graft may be necessary. The essential requirement is the removal of all badly injured tissue regardless of dimension depth or parts involved. Proper surgical treatment insures immediate cessation of severe pain and prompt recovery and there is no 'x ray skin' to be a menace throughout life. Excellent results are often obtained with the fresh jelly like substance from the leaf of the *Aloe vera* plant. The ulcer is dressed twice daily with this substance. Proprietary preparations containing *Aloe vera* have not proved satisfactory.

Areas of chronic radiodermatitis require no special treatment unless there is immediate danger of cancer in which case excision or a plastic operation is indicated. Also such treatment may be indicated for cosmetic or esthetic reasons or for relief of impaired function as for instance ectropion, sclerosis of buccal commissures, etc. Tilted glectasia can be made less conspicuous by means of blistering doses of water cooled ultraviolet rays administered under pressure or by means of electrolysis or the high frequency current. Nothing can be done for atrophy except excise the area. Individual keratoses when small can be destroyed with electrodissection. They can be temporarily eradicated with x rays or radium but most authorities believe that such treatment is contraindicated.

**Radium Injuries**—These are essentially the same as those caused by the roentgen rays but there are detailed differences. Beta rays from radium element or radon (radium emanation) are comparatively superficial in effect therefore the injury is more superficial repair is more rapid and more complete and there is less likelihood of disfiguring and dangerous sequelae. Nevertheless the more penetrating beta particles can cause a serious injury to the true skin. Implantation of radon may lead to serious injury to the subcutaneous tissue bones vis-

cera etc. Heavily filtered gamma radiation administered from a distance may cause very serious injury to deep structures and viscera.

**Deep Injuries Caused by X-Rays and Radium**—Large quantities of heavily filtered x rays or gamma rays and the ingestion of excessive amounts of radioactive water may cause serious injury to subcutaneous tissues muscles bones and viscera. The pathology is essentially the same as that of radiodermatitis. The symptomatology depends naturally upon the particular part or organs affected.

Certain tissues are radiosensitive while others are radioresistant. Embryonic tissue young cells cells at or near the phase of division physiologically active cells and lymphoid tissue are radiosensitive but all other normal tissue is relatively radioresistant. The degree of damage depends on radiosensitivity the quantity and quality of radiation and the amount of absorption by overlying layers of tissue. Partial complete temporary or permanent azoospermia is easily effected. Irradiation of the ovarian regions may cause sterility. Abortion can be produced. The effect on the hematopoietic system may result in aplastic anemia lymphopenia etc. The gastrointestinal tract and other viscera may be functionally injured. Cataract can be produced. Severe injuries to important tissues may result in invalidism and death.

**Injuries Produced by Ultraviolet and Infra Red Radiation**—By infra red radiation is meant heat. Carelessly or excessively employed heat may produce severe and serious burns. Heat in susceptible persons causes the condition known as erythema ab igne.

Excessive exposure of large areas of the body to solar radiation or to similar radiation from artificial sources may cause serious illness and even death. Local burns caused by ultraviolet rays are uncomfortable but they heal rather promptly usually without leaving permanent sequelae. Frequent exposure to such radiation over a period of many years in the presence of idiosyncrasy or sensitivity may give rise to sailors or farmers skin a condition simulating chronic radiodermatitis and xeroderma pigmentosum. Ultraviolet radiation may pre-

precipitate an attack of lupus erythematosus and herpes simplex. It is a factor in the production of the symptom complex of pellagra and xeroderma pigmentosum.

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## V. THE SKIN AND SUBJACENT TISSUES

### WOUNDS

A wound is a solution of unity in any part of the body by an external instrument. They receive their differences from their magnitude, part wounded and their cause' (James Cook of Warwick). The repair of a wound is effected by the activity and growth of living cells save for what may be accomplished by contraction. The role of the different cells varies only to meet the demands of the wound. And when healing is complete the growth of new tissue from living cells ceases.

Viewed in this light it is perhaps helpful to regard every wound as a new growth in which paradoxically every effort should be made to promote its growth knowing that some biologic principle will terminate the process when healing is complete. With this idea in mind one is more likely to evaluate properly one's efforts to assist and what is probably more important to develop an alertness to meet the ever changing demands of different kinds of wounds or even of a given wound during the course of healing.

It is well nigh a law of nature that the growth of living things is best when food is ideal and when there are no handicaps to divert the energies of the cells from the process of growth. In a broad sense the physician's responsibility in connection with a wound is to endeavor to provide the cells which must grow and heal the wound with the best possible food and to rid them of the handicaps which may stunt their activities or even destroy them. It is perhaps not generally realized that all the established principles of wound healing have a rationale in one of the two aims. Let us now briefly review them.

**Necrosis, Debris, Foreign Bodies.**—These terms are self explanatory and have reference to the presence in wounds of substances other than the living cells of tissues. Discussed by Paracelsus (1493-1541) and dramatized into a legend at the battle of Danvillers in 1552 by Paré who ran out of boiling oil it has since become firmly

established that any of these substances in a wound is a definite handicap to the processes of healing. Dead or devitalized tissues not only serve as excellent food for the growth of bacteria but also divert the energies of living cells from the problem of repair to the problem of elimination of foreign materials.

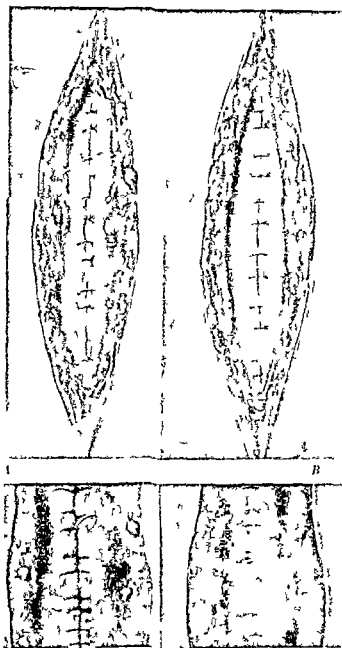
Foreign bodies or tissues long dead in a wound are easily recognizable by their appearance. But this is not enough. It is absolutely essential for the physician to realize that tissues deprived of their blood supply by trauma, tight ligatures and sutures must die even though at the completion of the repair of a wound no apparent changes can be detected in their appearance (Fig. 21).

**Rest.**—The value of rest to the processes of a healing wound was fostered by Baron Larrey and amply confirmed by Billroth and others. Motion in a fresh wound brought about by joint or muscular action disturbs the medium in which the cells are growing, and invites infection by causing minute hemorrhages and the death of countless delicate growing cells. Besides avenues for the spread of infection may be opened up in the granulation tissue. This principle is applicable to all wounds, not just those involving bones.

**Blood Supply.**—The living cells which heal a wound must in the final analysis receive their energy from the circulating blood. This is readily observed in the vast differences in the healing of wounds in sick and in well aged and young debilitated and robust persons. In the treatment of a wound it therefore becomes the physician's obvious duty not to neglect any measures that will enhance the blood supply to the area involved. A consideration of this factor will indicate to the thoughtful surgeon the position in which the wound should be kept in order to secure for it the maximum blood supply. The crippling effect of excessive edema on blood supply will indicate the necessity for elevation of an injured extremity and the avoidance of tight circular dressings.

with a tourniquet like effect. If the arterial supply of the part is greatly reduced as compared with the venous return it may be

be used only to approximate living tissues not to strangle them and therefore should be tied no tighter than to accomplish



wise to use a dependent position. With due consideration of this principle of blood supply one can imagine a wound literally crying out to the physician that sutures are to

gentle approximation that ligatures are for the purpose of controlling hemorrhage and not strangulating to death the living cells and should therefore be tied no tighter than

is required by the simple need of controlling hemorrhage.

Not only is the quantity of the blood supplied to a wound important, but also its quality. It has been shown by Thompson, Ravdin and Frank that hypoproteinemia seriously retards wound healing in the experimental animal by interfering with fibropla-

When available, laboratory determinations of the hematocrit, plasma proteins, blood chlorides and vitamins give useful information as to the condition of the blood.

**Hemostasis.**—Hemorrhage in a wound separates living tissues and increases the amount of work the living cells must do to bridge the defect. It is a good medium for

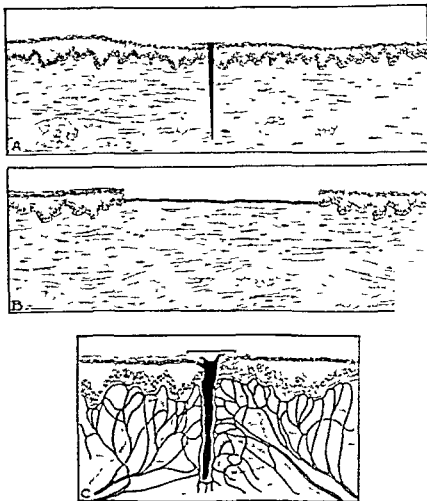


Fig. 22.—Schematic illustration of (A) a closed fresh wound, (B) a fresh open wound and (C) the secondary closure of a granulating wound. In all three instances the healing processes are essentially the same. The film (represented in solid black) serves as a medium for the growth of granulation tissue and epithelium.

sia. Severe degrees of vitamin C deficiency likewise prevent strong wound healing, though by a different mechanism—interference with the formation of the intercellular cement substance. Lanman and Ingalls have reported excellent laboratory experiments on this point, and Lund and Cranston have performed human experiments that indicate that minor degrees of C avitaminosis probably are not very important from the standpoint of wound healing.

the growth of bacteria and thus encourages the development of infection. By tension it interferes with the blood supply of living cells and retards their growth. In effect it is a foreign body that must be removed. Yet the securing of ideal hemostasis does not justify the use of unnecessary ligatures and sutures, for they, too, are foreign bodies and interfere with blood supply.

**Granulation Tissue.**—Granulation tissue is essential to the healing of every wound

In this sense there is no difference except in degree when a wound heals by first second or third intention whether it is clean or infected. In a clean wound accurately approximated the granulation tissue grows in the medium in the small crevice between the cut edges and the epithelial cells grow over the narrow surface (healing by first intention). If the epithelial edges are widely separated the granulation tissue grows in the medium on the surface of the wound and epithelium grows over the wide gap

a poor blood supply the growth of cells to heal the wound cannot proceed.

Besides the essential part granulation tissue plays in healing of a wound it is in the absence of epithelial and endothelial protection the body's best defense against the invasion of bacteria. Years ago Billroth reported the following experiments to his students. If you inject a drachm of putrid fluid into the subcutaneous cellular tissues of a dog the result will be inflammation fever and septicemia. If you make a large

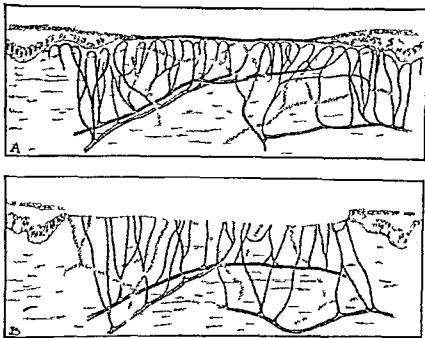


Fig. 23—4 A granulating wound showing new growth of epithelium from the wound edges into the fibrin. The vessels and the lymphatics are closed. When there is no traumatization there is no absorption and the underlying tissues are best protected. B An open fresh wound without fibrin showing the open vessels and lymphatics. Absorption takes place rapidly from such a surface.

(healing by second intention). When the edges of a gaping granulating wound are approximated the granulation tissue grows in the medium between the approximated surfaces and the epithelium over a narrower area (healing by third intention). There is no essential difference even though as shown in Fig. 23 B and C there is usually infection and in C there are always bacteria which may or may not give the clinical evidences of infection. Essential to the healing of any wound is this medium (coagulum) in which grow the cells which form granulation tissue and epithelium. When it is destroyed by bacteria, chemicals or dressings or when its formation is prevented by

granulating surface on a dog and dress it daily with charpie soaked in putrid fluid it will have no decided effect. On the borders of the inflammatory new formation the lymphatic vessels are closed on the granulating surface there are no open lymphatic vessels hence no absorption takes place. Therefore protection of the granulation tissue and its surface cell medium from traumatization and insults of any nature becomes of paramount importance in the consideration of wound healing (Fig. 23).

**Temperature.**—The effect of temperature on the growth of cells in vitro or of bacteria on a culture medium is well known. It is probable that the ideal temperature for the

healing of a wound is normal body temperature and that an effort should be made to approximate it with regard to the dressings and atmospheric conditions for a wound.

**Bacteria**—Infection is the greatest handicap to the healing of wounds but it is certain that bacteria often receive the blame when in reality the infection is due to failure of the surgeon to observe some of the fundamental principles of wound healing. All wounds even though made by the surgeon with the most meticulous asepsis receive some bacteria on their surfaces. The sterility of a wound is relative and cannot be made and kept absolute by any known means. In this sense practically every open wound possesses the potentialities in varying degrees of becoming clinically infected. Many times the development of clinical infection is not due so much to the bacteria which healthy living cells could have handled but rather to the debris and necrosis left in the wound or produced by the surgeon's roughness, the necrotizing effect of too many tight sutures and ligatures or the use of germicides which destroyed countless delicate invisible living cells. This delicious bacterial food of debris and dead or devitalized tissue is frequently the kindling of a conflagration that need never have occurred. Yet bacteria receive the blame and the conscience of the surgeon goes free.

When considering the use of a bactericidal agent in an open fresh wound one is confronted with the fact that if the agent is capable of killing micro-organisms it is capable also of killing or damaging the delicate living cells. Surely the use of every bactericidal agent involves some sacrifice of the other fundamental principles of wound healing. The harm which has resulted from pouring antiseptics into fresh wounds can not be estimated.

The sulfonamides and penicillin are not generally classed with the other antiseptics and there is evidence that small amounts of these substances may be used without injury to tissues. The extent to which these agents should be used locally is still unsettled because of their great effectiveness when administered systemically. However many careful surgeons feel that it is advantageous to use them locally as well. Sulfanilamide is perhaps the safest of the sulfon-

amides for this purpose because its high solubility reduces its chances of caking.

From this brief consideration of bacteria in wound a few general rules may be deduced.

1 With regard to a deliberately planned or operative wound it is the duty of the surgeon (a) to reduce to a minimum by aseptic precautions the bacterial contamination of the wound and (b) to leave the wound in the best possible state to deal with the inevitable bacterial contamination.

2 With regard to a fresh traumatic wound it is the duty of the surgeon (a) to remove all foreign bodies or dead or devitalized tissues which are excellent encouragement to the growth of bacteria, (b) to remove in a way least harmful to the living cells the bacteria on the surface of the wound and (c) to leave the tissues of the wound in the best possible state to cope with the bacteria not removed.

3 With regard to an infected wound it is essential to realize (a) that organisms are growing, (b) that they have penetrated living tissues and may be destroying them, (c) that unnecessary cutting procedures may open up channels for widespread infection, (d) that drainage to the point of complete release of all tension is desirable, (e) that absolute rest of the part is vital and (f) that the harm to living cells from certain antiseptic solutions (especially Dakin's solution) may be outweighed by their value in the control of the infection. Within six hours from the time the wound is received it is usually safe to assume that the bacteria are on the surface and the wound may be treated as any fresh soiled wound. After six hours judgment comes into play as to whether the wound should be regarded as soiled or infected. This depends largely on the character and location of the wound, the severity of the soiling and the nature of the bacteria which may have entered the wound. If a wound is not treated until twelve or more hours after its occurrence it should be regarded as infected.

4 Open granulation tissue should be regarded as infected. There are always bacteria on its exposed surface, hence surgical trauma to such an area may lead to local exacerbation or even spread of this infection. Such areas should be encouraged to

close as promptly as possible. In the case of large areas this will usually require skin grafting after the bacterial flora has been rendered as favorable as possible by chemotherapeutic agents. With smaller areas it is sometimes justifiable to close the wound by secondary suture (healing by third intention).

### TREATMENT OF WOUNDS

'The proper treatment of wounds is to be regarded as the most important requirement for the surgeon' (Billroth)

In the treatment of a wound it is essential to remember that the life of the patient is important. Under conditions of extreme emergency, such as terrific hemorrhage, severe shock or other concomitant injuries, the use of many or even all the fundamental principles of treating wounds often must be modified or even completely ignored. A patient who needs blood or some other fluid intravenously for shock should not first have his wound treated. A patient with a fractured skull or a crushing injury of the chest may require nothing for a distant wound save a bandage and rest. I have thrust an unsterile finger unhesitatingly into a punctured wound of the subclavian artery in order to prevent the patient from bleeding to death.

In other parts of this book are discussed such conditions as shock, hemorrhage, fractures, injuries of joints, blood vessels, nerves, and viscera, and sucking wounds of the chest. In the remainder of the present discussion it is assumed that it is possible to treat the wound ideally; it must be realized, however, that the above named conditions and perhaps others may have to take precedence over the consideration of a wound. This point cannot be stressed too strongly for a wound is often treated at the expense of a life which may be hanging in the balance from some other cause.

It may be assumed that with the modern methods of technique there is not a wide variation in the actual bacterial contamination of surgical wounds. However, it is generally agreed that some bacterial soiling occurs in all so-called clean wounds. In many instances failure of the wound to heal properly is directly traceable to the burden of insults unnecessarily heaped on the tis-

sues by the operator and his assistants. Viewed in this light there was never a truer statement than that of Homans in which he says: 'The patient's best defense against infection lies in the perfection of the operator's technique.' In the performance of identical operations and with presumably the same bacterial contamination, one surgeon may obtain an infected wound while another may obtain primary healing.

The obvious conclusion from these facts is (1) to leave the cells of the tissues of the wound in the best possible state of health to combat the bacterial contamination and (2) to remove from the surface of the wound without damage to the living cells as many as possible of the bacteria.

There are many ways in which a surgeon can make an effort to leave the tissues in the healthiest condition. It is important to plan the incision so that the operation will interfere least with the blood supply and so that all skin flaps and surfaces of the wound will receive an adequate supply of blood for the growth of living tissues. Sharp dissection with a knife is least damaging to living tissues. The long ends of blood vessels that project beyond a ligature should be removed. As few clamps as possible should be used when ever clamps are necessary. A definite effort should be made to grasp only the bleeding vessels. Pressure with gauze for a few moments on the freshly cut surface of a wound may reduce by 75 per cent or more the number of clamps which might otherwise have been used. The longer a clamp is left hanging in a wound the more thoroughly is the bite of living tissue devitalized. Tissues which in the judgment of the operator will not bleed on removal of the clamps should not be tied. All non-viable tissue whether caused by ligatures, sutures or trauma should be excised if possible. The use of clamps on the peritoneum and other tissues solely for the purposes of traction should be eliminated or reduced to a minimum. The long-continued use of self-retaining retractors may produce venous necrosis. The wiping of fresh wounds is inexcusable and worse than throwing pepper into the eyes of an infant. The blood can be just as effectively removed by suction, flushing with normal salt solution or the gentlest sponging and with infinitely less damage to the living cells. Sutures

should rarely, if ever, be employed in fat or muscle; they inevitably lead to early necrosis and are of little value as far as approximation is concerned. The fact that tight sutures in the skin may lead to a cutting necrosis is a strong hint as to their effect on the more delicate underlying tissues.

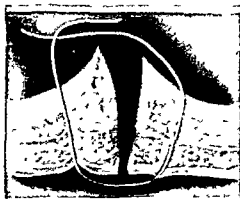
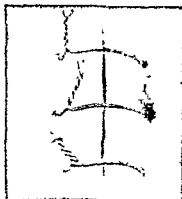


Fig. 24—Illustrating the through and through silver wire closure of a contaminated abdominal wound. This method avoids the foreign bodies of the sutures in the wound and also disturbs the blood supply much less than the usual layer closure.

Foreign body drainage of a "clean" planned wound by means of drains or tubes is almost never employed. When there is known to have been serious bacterial contamination or when there is likelihood of considerable oozing of blood, deliberate provision is made for gaps between the skin sutures. In the case of such a wound in the abdomen, no sutures are placed in the line

(Fig. 25). The wound is placed in the position of optimum circulation and kept immobilized when necessary, especially during the period of recovery from anesthesia. Unless indicated by pain or evidences of infection or hemorrhage, the wound is left undisturbed until it is thought desirable to remove some of the stitches.



**Traumatic Wounds.**—In the case of all traumatic wounds, bleeding of any consequence is first controlled, preferably by elevation of the part and direct pressure on the wound or, when absolutely necessary, by clamping individual vessels. In the hands of a competent surgeon the use of a tourniquet to control hemorrhage from a wound is rarely necessary.



Fig. 25—A diagram showing the method of dressing a fresh traumatic wound which has been properly cleaned and closed.

of incision, in order to avoid their necrotic effects; instead, the wound is closed with through and through silver-wire sutures, far removed from the edges of the wound (Fig. 24). Moist dressings are applied and kept moist for a considerable time by means of a rubber protective so that tension of the wound may be relieved by seepage during the period of edema or slight hemorrhage

Traumatic wounds may usually be classified as incised, contused, lacerated, penetrating or complicated or as due to animal or insect bites. These designations are self-explanatory, being used to indicate the main attribute of the wound or its etiology.

**Incised Wounds.**—In the case of a simple incised wound, when inspection reveals no damaged tissue, the problem is largely

one of controlling hemorrhage and washing the wound and surrounding skin in a manner that will do the least harm to living cells and yet will remove the blood clots and the vast majority of surface bacteria. Harmless bleeding during the process of washing may help to remove the bacterial contamination of the surface.

In the case of the cleaner wounds produced by relatively sterile objects cleansing of the surrounding skin with soap and water, alcohol and ether and careful irrigation of the wound with sterile salt solution or water will usually suffice. When fine particles of dirt have been ground in or the tissues have been stained with grease, tar or some other substance, gentle but thorough cleansing of the wound with a soft sponge and white soap should precede the irrigation with salt solution or water. Good tap water may be used without hesitation when sterile water or salt solution is not available. For this a general or local anesthetic may be required. Each has its disadvantages but it is well to remember that procaine and most of the other local anesthetic agents are derivatives of para-aminobenzoic acid and that they antagonize the bacteriostatic action of the sulfonamides.

After thorough but gentle cleansing the wound may be lightly dusted with sulfonamide powder; the harsher antiseptics which are used for skin preparation should not be used.

After the surrounding skin and wound surfaces have been carefully cleansed the field of operation has been re-draped and the operator's glove has been changed the wound is repaired as indicated with out any drainage. Only the very essential sutures for the repair of nerves, tendons and fascia are buried in the wound. The skin edges are approximated loosely and a moist dressing as previously described is applied. For a small incision approximation of the skin edges with strips of sterilized adhesive tape often suffices.

**Contused Wounds.**—When the skin is visible and the associated deeper injuries such as to blood vessels or a viscus do not demand treatment it is always better not to convert a contused wound into an open wound. The skin even though severely excoriated may yet serve as an excellent protection

against bacterial invasion. It should of course be carefully cleansed with soap and water and irrigated with salt solution or water. Single or repeated aspiration of old blood may keep an endangered skin from sloughing. moist warm fomentations of boric acid or salt solution may enhance the circulation to the point of survival of the skin.

When the skin is completely broken or damaged to the point of inevitable sloughing it is better to open the contused wound and treat it as though it were a lacerated wound.

Absolute rest may be vital to the healing of a contused wound; it prevents further trauma from muscular motion and decreases tension by lessening hemorrhage and edema.

**Lacerated Wounds.**—All bleeding of any consequence is first controlled preferably by elevation of the part and pressure or when absolutely necessary, by clamping individual vessels or using a tourniquet. The skin about the wound is shaved, washed with white soap and water, alcohol and ether and possibly painted with some non-irritating skin antiseptic. None of the alcohol, ether or antiseptic should enter the fresh wound. Next sterile draping is done as though for a clean operation. If any clamps were placed to control hemorrhage they are held up by an assistant during the preparation of the skin. If the operation is to be done under local anesthesia the infiltration of the skin is made well away from the edges of the wound. With this preparation the clamps are removed (now under a tourniquet if necessary) and the wound is packed with a piece of dry gauze. The wound as well as the skin edges is now carefully excised by sharp dissection. During this process it is desirable to protect the new raw surface with moist flat gauze sponges and not to contaminate the wound further by exposing the dry pack. Often the wound with the gauze pack inside can be removed *in toto* without any serious break in technique. At the completion of the debridement the tissues should appear healthy. For fat and subcutaneous tissues the appearance is the best guide for muscles their ability to contract is a useful guide.

The wound is now ready for careful wash



ing with sterile water or salt solution. During this process, the wound is usually rubbed gently with the gloved finger. If, for any reason, complete excision cannot be performed, such as the presence of exposed nerves, blood vessels and grease-stained or dirt-stained living tissues which should not be excised, it is often essential to scrub the wound with white soap and water before using the salt solution. In certain locations, particularly on the face and scalp where it is usually desirable to save every bit of viable tissue, it is often best to begin with soap and water in order to remove all dirt

there will be free seepage from the wound into the moist dressing. Usually it is far better to use no skin sutures which may in any way imperil the blood supply to either side of the skin edges. To tack a flap of skin loosely back one-half inch or more from the opposing edge is one of the hardest things in the world for a young surgeon to do. An avulsed flap of skin is far more useful alive and unsutured than dead from the anemia of the tension of the sutures which place it "beautifully" back into position. Besides, wound healing is less complicated if there is no sloughing after the debridement. It is

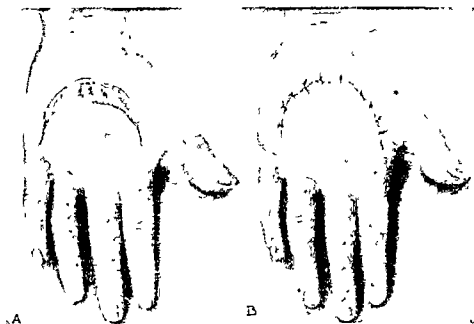


Fig. 26.—*A* An avulsed flap of skin laid back in place, unsutured but viable. *B* An avulsed flap of skin sutured and doomed to necrosis as a result of anemia due to tension. In *A* a very slight scar results. In *B* skin grafting is often necessary.

and grease and then to follow this by trimming away the obviously devitalized tissues and the ragged skin edges in preparation for proper closure of the wound. After this, the wound is washed with salt solution as though a complete excision had been done.

After the operative and cleansing procedures, the skin around the wound is again cleansed, dried and repainted with an antiseptic, gloves and gowns are changed, new drapings are applied and a fresh set of sterile instruments and supplies is employed for the closure.

The fewest possible ligatures and sutures are placed in the wound. Skin sutures are tied loosely and are widely spaced, so that

amazing with how little scarring even a large open wound will heal if there has been little or no loss of skin (Fig. 26).

Many factors may make it inadvisable to close a lacerated wound even after debridement; among these are the generally poor condition of the patient, the poor blood supply, the great loss of skin and subcutaneous tissues, the incomplete debridement, unusually virulent soiling and the attempt to save vital structures that cannot be satisfactorily cleansed. In such instances the wound may be dusted with sulfanilamide crystals, filled with petrolatum gauze, dressed and immobilized for many days, unless pain or fever indicates the presence of infection.

After the protection of granulation tissue has formed the wound may be closed by the grafting of skin or secondary suture. Experience in the management of war wounds has led many military surgeons to use this method routinely, at least for all major injuries.

In some instances where there is doubt about the completeness of the toilet of the wound or where the patient's condition does not justify primary closure the wound may be prepared for delayed primary closure. It is simply packed loosely with gauze moistened in salt solution or a solution of sulfur thiazole and immobilized for from one to three days. If the wound looks clean and uninfected when the gauze is removed it may then be closed.

It must be realized that there are many conditions and circumstances under which the ideal therapy of a traumatic wound is unpracticable. Under such circumstances the only course of procedure is to make a logical compromise. Perhaps this can best be illustrated by relating the following personal experience.

Not long ago a friend brought his boy hurriedly to my home because of a laceration of the end of the thumb. If the boy had not held his wound under running water the father would not have been so worried; he would have put some iodine on it and wrapped it up. As it was he was afraid of an infection from the water. He was therefore surprised when after cleansing the skin about the wound with benzoin and then cutting away some dead fragments of skin, I had the boy sit on a stool by a sink and run warm water over the wound. After the lapse of ten or fifteen minutes while the father and I discussed fishing a large amount of petroleum jelly was placed on the wound and secured in place by a soft dressing incorporating a splint to immobilize the thumb. The hand was then placed in a sling. The father was instructed not to bring the boy for an inspection of the wound for a week unless he showed an elevation of temperature or complained of pain. No antiseptics were used in the open wound. There was practically no pain or fever. At the end of a week the wound was healed.

The father like thousands of other persons of his generation had been imbued since birth with the necessity of using iodine or some antiseptic to kill the germs in a wound. He had never seen a wound like that heal without becoming red and painful. He could not understand why I had used a splint or cut away the fragments of dead tissue. To him the one essential on such an occasion had always been to kill the germs at whatever cost in pain, suffering and infection.

This father's attitude reflects I believe the viewpoint of the average layman today with regard to the

handling of trivial wounds and probably that of the vast majority of physicians with respect to all wounds.

**Penetrating Wounds.**—These wounds may be particularly serious because of the implantation in them of foreign substances such as boot leather clothing or stable dirt. Besides, the anaerobic conditions of such wounds especially encourage the growth of the tetanus organism. The treatment naturally varies with the appearance of the wound, its location and the circumstances under which it occurred. Puncture wounds from high velocity bullets, clean instruments or objects long exposed to sunlight and drying are often best treated by careful cleansing of the points of entrance and exit, immobilization and a position of optimum circulation while those from shrapnel slugs or nails about a barn or in moist earth will demand the complete excision and therapy described for lacerated wounds. When there is fear of tetanus or dissatisfaction with the debridement it is far better to leave a wound wide open to heal by secondary intention (See the section on Tetanus). The clothing may be a determining factor. In a war in China one winter most of the missiles carried sheep's wool into the tissues and consequently had to be excised.

**Bites and Stings.**—The bites of animals, especially those of human beings, are unusually dangerous. The wounds are deeply inoculated with a great variety of microorganisms which often appear to work synergistically to produce extensive necrosis and cellulitis. When such a wound is seen in the first six hours it should be completely excised if this is possible. Unfortunately many of these wounds occur on the hands where little tissue can be sacrificed. Here the wound should be laid wide open thoroughly cleansed and packed open. The part is splinted and chemotherapy instituted.

When the animal is known to have had rabies, the Pasteur treatment or one of its modifications should be instituted promptly. This is usually necessary also when the animal cannot be traced. If the animal appears normal the proper course is to keep it under observation and start antirabies treatment of the patient only in the event that the disease develops in the animal.

Insect bites except those bearing a strong poison such as that of certain spiders, had

best be treated by surface cleansing and moist dressings and afterward if necessary as infected wounds. The wounds inflicted by certain snakes, spiders and other poisonous insects should be completely excised, cleansed and not closed. Antivenoms have been developed for many of these poisons and should be used promptly. Even when the species of snake is not known it is often practical to use a polyvalent antivenom made up for all of the poisonous snakes prevalent in the region of the accident.

**Complicated Wounds**—Most of these conditions are considered elsewhere in this volume under such subjects as injuries to the thoracic and abdominal viscera, compound fractures, open joint injuries and lacerations of nerves, tendons and blood vessels. Even in such wounds the fundamental principles of wound healing discussed in the first part of this section obtain; they are modified only to suit the peculiar conditions.

**Infected Wounds**—Infection of a wound differs from soiling in that organisms have started to grow and may have invaded the living tissues. Under six hours it is reasonable to assume that this growth has not progressed very far and the wound may be treated as one with surface bacterial contamination. (This section is not concerned with the treatment of spontaneous infections: boils, carbuncles, erysipelas, lymphangitis, tenosynovitis, fascial space infections and other conditions which are discussed elsewhere in this book.)

**Prevention of infection** in a deliberate or planned wound is the real cornerstone of modern surgery. By and large it is being done fairly satisfactorily, although a more conscientious application of all the principles of wound healing would improve the results. The real problem of today is prevention of infection in accidental or traumatic wounds, since the use of iodine and other powerful antiseptics has had hold alike of laymen and physicians. Not only do these antiseptics not disinfect wounds, but their use has led to a shameful disregard of most of the cardinal principles of wound healing and consequently an untold number of unnecessary infections. The substitution of sulfonamide preparations either as fine crystals or a dusting powder (microcrystals) or

ointment in a water-soluble base is accomplishing much to remedy this tendency.

It is obvious from what has been said that wounds which by reason of lapse of time may be regarded as infected and those which may be regarded as soiled but which cannot be satisfactorily cleaned should after the primary treatment be left open and managed for healing by second or third intention.

The fire of a clinically infected wound may vary from a flicker to a conflagration; it may readily go out or it may lead to suppuration, great damage of living tissues, septicemia or pyemia. The treatment of infected wounds must necessarily be almost as varied as the nature and character of the infections.

The care of infected wounds is not by any means solely a problem of drainage and germicidal therapy. In fact incision should usually be avoided in the presence of lymphangitis and cellulitis unless there is actual suppuration. Except in rare instances in which the swelling in an area of cellulitis imperils the blood supply, it is wiser to devote twenty-four hours to systemic chemotherapy, rest (both general and local) and warm moist dressings locally. If it is then necessary to operate, the chance of spreading the infection is diminished. Prior to actual suppuration it is difficult to justify any incisional measures in the treatment of an infected wound. The price to be paid in the nature of traumatization, necrosis and the opening of new avenues for the spread of the infection is not often warranted.

When suppuration has occurred however, some form of *external drainage* becomes necessary sooner or later in order to avoid the damage of tension, accumulated toxins and spread of the infection. Deciding when to do this must obviously vary with the nature of the infection. In the case of a mild infection when the human tissues are throwing up a barrier of granulation tissue and beginning to localize it, a non-operative procedure may often be profitably employed for a time before external drainage is established. In such cases when the time does arrive to release the tension of the pus, a small reopening of the wound and gentle irrigation with salt solution or Dakin's solution will often effect a speedy healing. At

the other end of the scale occur the rapidly developing infections and suppurations due to virulent organisms against which the living tissues are unable to set up any effective barrier. The patient has a high fever and becomes sick and toxic his resistance becomes lower and the blood stream may contain organisms. The immediate complete reopening of such a wound is imperative and debridement should be employed until the infection subsides and healthy granulation tissue covers the surface of the wound. Surgical measures such as transfusions intravenous administration of fluids use of chemotherapeutic agents and fixation of the part should not be overlooked. (For the treatment of gas gangrene hemolytic streptococcal gangrene or erysipelas in or around wounds see sections by Meloney and by Christopher.) In the case of tetanus the wound is usually excised or laid wide open and serum and sedatives are administered as advocated in the standard treatises on the subject.

Between the two extremes of the mild and the fulminating infections of wounds there are many grades which consequently demand almost as varied forms of therapy. Strictly speaking it is doubtful if any two infected wounds can be absolutely alike. In most cases therefore a decision as to what should be done can be reached only after a careful study of each individual instance of suppuration as it arises. This means a conscientious effort to evaluate the capabilities of the tissues involved and of the patient as a whole, of weighing carefully the good and the harm of whatever procedure may be contemplated. Between the conservative and the radical procedures modifications must be made to suit the demands of the intervening grades of infected wounds. It may be added that once the decision is made to open an infected wound the general tendency is to be too conservative. Wide opening is preferable in order to avoid as much as possible the traumatization due to such foreign bodies as gauze drains and tubes. Hot fomentations and irrigations with fluids not harmful to living cells are usually most helpful.

**Tetanus and Gas Bacillus Infections —**  
The question of the use of tetanus antitoxin should arise in connection with the treat-

ment of every traumatic wound. When the physician would not give it to himself or his family in the case of a given wound it is wise for him to say so to the patient or his family in order to share the responsibility of the slight risk involved. In the case of a penetrating or soiled wound received under circumstances that are at all likely to cause the introduction of the tetanus organism the use of antitoxin must be insisted on. This is especially necessary in the case of a gunshot wound or of a puncture wound of the sole of the foot. I well remember as a youngster watching the agonies of a friend who died after stepping on a nail in a barn yard.

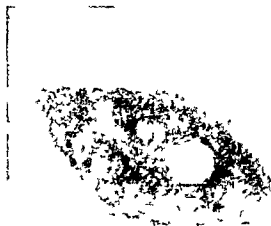
The prophylactic dose of tetanus antitoxin for adults is usually 1500 units which may be repeated in seven to ten days if the likelihood of tetanus is very great. In every case the patient's sensitivity to horse serum should be investigated both by questioning him or his family and by making small intracutaneous tests. There is now on the market a bovine tetanus antitoxin to which a patient who is sensitive to horse serum may not be sensitive. When there is sensitivity to the serum to be used it is imperative that the patient be desensitized by means of repeated small injections before the entire amount is given. In some cases of unusual hypersensitivity it is wise to hospitalize the patient during the administration of the antitoxin.

If a patient is found to be sensitive to horse serum it is well to advise him to be immunized later with tetanus toxoid. At present this requires several weeks and is not a suitable means of protecting the patient from an injury already sustained. However the immunity conferred lasts much longer and may be renewed promptly at any subsequent time by a booster dose. Most of the men in the armed services have received tetanus toxoid and for them an additional dose of toxoid should provide ample protection.

A wound suitable for the growth of one species of clostridia is apt to be suitable for the growth of others so that there is an increasing tendency to use a polyvalent serum which is also effective against the common strains of gas bacilli wherever tetanus antitoxin is used. Such prophylaxis is

a valuable routine in the management of wounds resulting from traffic accidents and compound fractures and in all wounds in which there is extensive devitalization of muscle.

#### Use of Sulfonamides in the Treatment of Wounds.—The sulfonamides have been



A



B

Fig. 2.—A. Skin graft on an intensely devitalized wound. There is no fibrin or growth of epitelium. B. Condition of the same wound after 48 hours of intensive devitalization. Note the coating of fibrin which forms a medium in which new cells grow. Rapid epithelialization has begun.

widely accepted in the treatment of contaminated and infected wounds and their use is so logical that it may be regarded as an established practice likely to be supplanted by newer chemotherapeutic agents but not likely to fall into disuse for any other reason.

Clean wounds, although probably contaminated to a slight extent in most instances have not often been treated prophylactically with the sulfonamides because the

advantage of doing so seemed to be outweighed by the risk of sulfonamide sensitivity.

At present sulfadiazine appears to be the drug of choice for systemic administration and sulfanilamide crystals the most suitable preparation for local application in wounds. It has not been definitely shown that local application improves the results obtained with systemic administration but it affords a prompt and intense sulfonamide effect in the local area. Zintel and his associates have studied the influence of these drugs on wound healing and have shown that as employed in their experiments they do not delay recovery of the tensile strength of the wound.

It cannot be too strongly emphasized that these drugs should not be used to cover careless technique but it is difficult to deny that their use has favored more limited debridements especially in wounds of the hands and face when it is essential to save as much tissue as possible.

**Use of Penicillin.**—The antibacterial substance elaborated by the mold *Penicillium notatum* has been found extremely effective in combating infections caused by the gram positive cocci gonococcus meningococcus and certain of the clostridia. It is ineffective against the colon bacillus and most of the gram negative organisms. Its great advantage over the sulfonamides is its extremely low toxicity and its great effectiveness against the staphylococci. Its use in treating hand infections is especially noteworthy but it will undoubtedly prove to have a wide range of usefulness in treating surgical wounds.

**Granulating Wounds.**—It is obviously essential that anyone charged with the responsibility of treating a granulating wound should have clearly in mind what he wishes to accomplish. If secondary closure is desired intensive antibacterial therapy should be given until the wound is macroscopically free from necrosis and exhibits a minor degree of bacterial contamination in smears and cultures of its secretions. This seems the wisest course to follow in preparing granulations for the reception of any kind of skin graft. If the granulating surface is merely incidental to some deep seated more impor-

tant pathologic process, such as osteomyelitis, it is often most illogical to treat it at the expense of rest and non-traumatization that are clearly indicated for the more important underlying process. The granulations, if not interfered with, will nearly always provide adequate protection to the body against invasion of bacteria, while the principle of rest is adopted in treating the other condition. If, however, the time arrives when there will be no, or very little, sacrifice to deep healing, then efforts to promote epithelization of the granulations by skin grafting or otherwise up to the point of sinus may be begun.

By far the most frequent problem in connection with a granulating wound is simply to get the epithelium to grow over the surface either from the edges or from islands of grafted skin (Fig. 27). Reduced to its simplest terms, the main problem is to have the granulating surface covered with the best possible medium for the growth of epithelial cells. Thus, practically all granulating wounds should be so handled that this medium will form to the best advantage even in the presence of infection, for without any medium the epithelial cells cannot grow.

Dakinization or antiseptic therapy may be so thorough and energetic as to make a granulating surface practically sterile and have a healthy, red, firm appearance; yet no epithelization will occur. The more modern chemotherapeutic agents have largely displaced Dakin's solution in the preparation of granulating areas for skin grafts (Fig. 27). Coarse gauze placed next to the surface may cause bleeding that will interfere with grafting (Fig. 28).

Finally, if the physician proposes to treat a granulating wound intelligently, he must keep constantly in mind the process by which it must eventually heal; he must be willing to change his procedures to meet the demands of the wound. If the process is being held up by the presence of slough, measures must be taken to assist in its separation. If the process is delayed by malnutrition, efforts should be directed to correct the nutritional deficiency. If infection is preventing successful skin grafting, chemotherapeutic agents will probably be required. If epithelization is prevented by an

overgrowth of granulation tissue, the excess tissue may require cauterization with silver nitrate or surgical removal. There are times when moist dressings are helpful and times

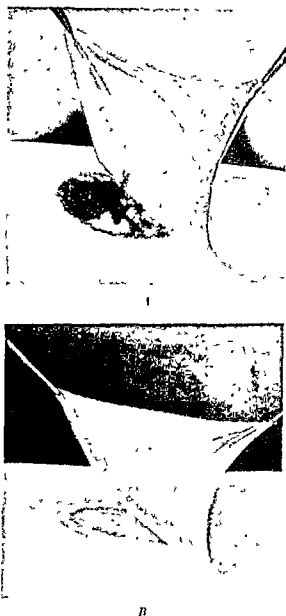


Fig. 28—A The effect of removing a dry gauze dressing from a granulating wound. Note the bleeding and the removal by the gauze of the delicate fibrin covering the wound. B The effect of removing a vaselined old linen dressing from a granulating wound. Note that there is no bleeding and the delicate layer of fibrin is not disturbed.

when healing seems to be furthered by exposure to air. Gradually, the exact indications for the various forms of treatment are being learned, but there are still times when one must study the individual wound from

day to day and direct the treatment by the response observed

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## SURGICAL INFECTIONS OF THE SKIN AND SUBJACENT TISSUES

Surgical infections of the skin and subjacent structures include a rather large and important group of lesions many of which however because of their location and the involvement of other structures are considered elsewhere in this volume.

The skin is ordinarily resistant to infection. The superficial layers of cells normally harbor numbers of bacteria particularly of the staphylococcus group. In the healthy person the organisms rarely cause trouble and wounds heal readily without becoming infected.

Infections occur when the resistance either local or general is lowered and their seriousness depends on the relation between the lowered resistance and the virulence of the offending organism. A third factor of importance in determining the course and character of these infections is the relation of anatomical structures.

Infection of the skin may occur without

any evidence of a preceding wound or it may be secondary to an injury with a break in the skin. It is quite probable that in all cases some trauma has preceded the infection although it may amount to nothing more than irritation mechanical or chemical.

The lesions considered here are lymphangitis, furuncle, carbuncle, felon and paronychia.

### LYMPHANGITIS

(See section on *Lymphangitis*)

### FURUNCLE

(Boil)

Furuncle is a type of infection which occurs without any evidence of a preceding wound. It is apt to be preceded however by some irritation such as the rubbing of a stiff collar on the neck, shaving with a dull razor or some other mild degree of trauma and is frequently seen in patients during a prolonged illness such as typhoid fever. It is especially liable to occur in diabetic and nephritic patients. The infection is caused by a staphylococcus and involves a hair follicle or a sebaceous or sweat gland. It may occur anywhere on the body but has a special predilection for hairy surfaces. A series of boils is apt to occur in a person whose resisting power is below normal as a result of some debilitating disease.

The bacteria after gaining entrance to a hair follicle set up a reaction attended with hyperemia and resulting in a migration of leukocytes into the infected area. Some of the leukocytes are destroyed by the toxins present and liquefied forming pus. Soon the defensive reaction obtains the upper hand and a definite wall of leukocytes surrounded by a zone of hyperemia is formed. The central area of necrotic tissue forms a slough (core) which is finally extruded after which healing takes place by granulation. The degree of infiltration is extremely variable and depends on the virulence of the organism and the defensive reaction present.

Ordinary boils are not attended by serious complications and are not dangerous to life. Their seriousness however is dependent to a great extent on their location. It

is generally known that furuncles on the face and particularly on the upper lip and in the nares are attended with a very high mortality rate. This is due to the fact that there is a communication between the anterior facial vein and the cavernous sinus and that septic material may be conveyed to the latter by a retrograde thrombosis. Metastatic infection may occur from boils in other locations. Osteomyelitis and metastatic abscesses to internal organs have been reported as occurring secondarily to furunculosis.

The average boil starts with a small red elevation which is extremely tender to touch. The area of redness extends gradually and is the seat of throbbing pain. The center becomes white or yellow from necrosis of the skin and finally opens spontaneously unless it is incised. A small amount of pus is discharged and tends to form a crust over the small opening. After several days the necrotic center is discharged and the pain and tenderness disappear gradually. The indurated area remains for a week or more and gradually disappears.

The degree of pain is variable and depends a great deal on the location of the lesion and on the depth and extent of the infiltration. There may be a mild general reaction. Unless great care is exercised infection of other nearby follicles occurs and a succession of boils results.

**Treatment**—Much has been written about the treatment of boils and many different methods have been enthusiastically advocated. Surgical treatment varies from rather radical early incision to extremely conservative treatment. Treatment in the past few years has swung to the conservative side and it is generally considered that boils on the face are more safely handled without incision or trauma of any kind. The admonition *Noli me tangere* seems particularly applicable in these cases as squeezing or otherwise traumatizing boils in any location is fraught with the danger that the protective wall will be broken down and the infection spread.

The application of hot moist dressings, delaying incision until localization and liquefaction have occurred and then resorting to a small crucial incision is probably attended with as good results as with any treatment.

[Softening unguents have some value—Ed.]

The method of introducing phenol into the necrotic center with a toothpick or other instrument probably lessens pain and hastens the separation of the slough. Attention to the general health of the patient is important particularly the appropriate treatment of diabetic or nephritic patients. The use of autogenous vaccines has been attended with success especially in recurring attacks of furunculosis. [Treatment by means of injections of staphylococcus toxin is helpful in some cases—Ed.] X-ray treatment especially in the early stage has proved of value in preventing pain and hastening resolution.

### CARBUNCLE

A carbuncle like a boil is a reaction of the skin and subcutaneous tissue to the invasion of a staphylococcus but it differs because of the greater virulence of the invading organism. An impaired defensive mechanism and also certain anatomic factors are of etiologic importance. Invasion takes place in advance of the defensive process and necrosis of subcutaneous tissue with liquefaction occurs over a considerable area.

Fibrous trabeculae interspersed with columns of fat extending up to the skin direct the destructive process in numerous channels. Multiple areas of necrosis of the skin develop and rupture discharging small quantities of pus. A protective wall of edema and leukocytes finally forms surrounded by a zone of hyperemia. The skin presents a honeycombed appearance surrounded by an indurated reddened area corresponding to the zone of edema and leukocytic infiltration. The indurated area is tender and the patient may have moderate fever.

Free drainage is impossible on account of the intensive ramification of channels extending from the small openings deep into the subcutaneous tissues. Necrosis and sloughing are usually quite extensive unless early surgical intervention is practiced.

Carbuncles are often serious and in some instances extremely dangerous to life especially when occurring in persons who are suffering from some debilitating disease such as diabetes and nephritis.



Occasionally lymphangitis with lymphadenitis occurs and rarely invasion of the blood stream with septicemia and metastatic abscess. Septic thrombophlebitis may occur with fatal outcome. As a general rule however the prognosis is favorable and healing takes place after a considerable period of suffering and disability.

strips. 3 The use of a gridiron incision with out undercutting. There is a growing opinion that conservative measures result in shortening the duration of the treatment lowering the mortality rate and improving the cosmetic result. These conservative methods include employment of x ray vaccines, staphylococci toxoid and various

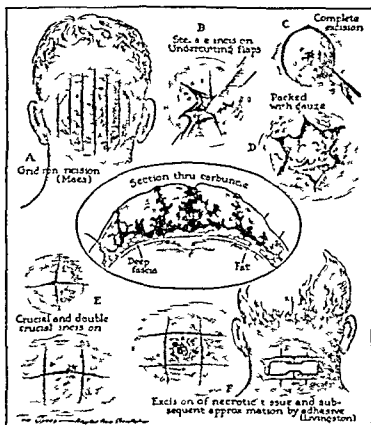


Fig. 29.—Types of incisions for earl nodes. One of the most useful incisions of all is the gridiron incision (A) but with the multiple parallel incisions made transversely across the neck instead of longitudinally as shown in the figure. This is particularly desirable when the earl node is in the middle of the back of the neck as it avoids the ugly scars produced by incisions which cross the skin creases.\*

**Treatment.**—While it is quite generally agreed that conservative methods are advisable in the treatment of boils many surgeons believe that carbuncles because of the anatomical factor involved require quite early and radical treatment in order to establish proper drainage and prevent extensive sloughing. These surgical procedures vary from simple incision to excision of the entire lesion with the radio-knife or cautery. The most generally accepted methods are as follows: 1 The use of a crucial incision extending into the zone of induration with undercutting of flaps. 2 The use of parallel incisions with undercutting of skin

topical applications. Sulfathiazole has been recommended in the treatment of both boils and carbuncles but as yet its value has not been determined. It remains to be shown whether or not penicillin may be effective in the treatment of these lesions.

#### FELON (Whitlow)

A felon is an infection involving the distal anterior portion of the finger. Its course is determined by the anatomy peculiar to this phalanx. The fascia attached to the bone at the epiphyseal line forms a closed

\* By permission of Johnson & Johnson.

space which is divided into compartments by trabeculae extending from the bone to the skin. These compartments contain columns of fat which are vulnerable to infection. Infection usually introduced through a trivial wound such as the prick of a pin or thorn is directed down the columns of fat to the bone.

It is possible that in some instances the infection is hematogenous in origin. Inflammatory reaction produces edema, swelling and the formation of pus. Since the connective tissue sac is extremely resistant enormous pressure develops and eventually shuts off the blood supply to the diaphysis with resulting necrosis and osteomyelitis. The epiphysis is not affected as it receives its blood supply above the connective tissue sac.

A sequestrum is formed and in children is usually found free in the resulting abscess. In adults the dead diaphysis is still attached.

Felon is attended with severe throbbing pain and extreme tenderness of the terminal phalanx. The patient may not be aware of having sustained a wound. There is a moderate amount of swelling in the early stage and if neglected there may be a brown edema. When the pressure becomes great enough to involve the nerves the pain may cease. If neglect is carried to this extreme marked destruction will have taken place. Obviously early diagnosis and incision are highly important in order to prevent the destruction of bone but unfortunately early diagnosis is not always easy. The marked tenderness of the phalanx usually determines the diagnosis. A throbbing pulsation is suggestive.

Although the joint is above the closed fascial space it becomes involved in some cases possibly by ill advised incisions and tenosynovitis may occasionally occur.

**Treatment**—The treatment of felon is immediate incision preferably under gas anesthesia as soon as the diagnosis is made. The incision should be placed laterally so that the resulting scar will not interfere with the tactile sense. It should completely open the closed fascial space without extending beyond it.

The hockey stick incision (Koch) is highly satisfactory. It is sometimes necessary to incise both sides in order to secure

adequate drainage. If after adequate incision drainage persists and exuberant granulations form the presence of a sequestrum should be suspected. Unfortunately early x-ray study gives little information as to whether necrosis has taken place.

The wound is held open with petrolatum gauze or gutta serena tissue. The drain should be left in place for two or three days. A hot wet boric acid dressing is usually

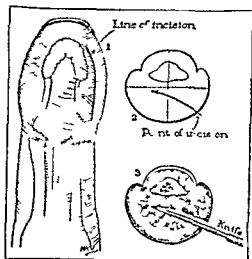


FIG. 3.—Illustration of a felon.

helpful. If a sequestrum has formed it must be removed. If all dead bone is removed the wound will heal promptly by granulation.

### PARONYCHIA

Paronychia is a common infection and may be extremely troublesome unless it receives prompt surgical treatment. Incision takes place through a torn hanging nail or some other slight wound and extends beneath the fold at the lateral border of the nail (paronychia). Slight swelling, pain and tenderness develop and there may be redness of the skin. A small incision parallel to the edge of the nail made at this juncture may disclose a drop or two of pus and the wound will heal with no further trouble. If neglected the infection follows the path of least resistance and burrows around beneath the eponychium and extends beneath the root of the nail, detaching it from its bed (subungual abscess). Pus may escape beneath the eponychium.

\* Koch J. M. A. 20

given in divided doses every four hours over the remaining twenty four hours. After twenty four hours the initial dose was reduced by one third and on the third day to one half. This maintenance dose was given for three to five days after clinical cure ensued to prevent relapse. Older children and adults were given similar treatment except that the dose was calculated at 1 Gm for 20 pounds (9 Kg) of body weight for twenty four hours. The average sulfanilamide level in the blood of 121 patients determined forty eight hours or more after admission was 5.8 mg per 100 cc. Vaccines, internal remedies, injections of antiseptics, and applications of contractile collodion outside of the advancing margin have little if any value. Cold boric acid compresses are generally comforting. Simmons and Lewis<sup>9</sup> believe that the streptococcus antitoxin marks a definite advance in overcoming the disease and reduces its duration 60 per cent and its mortality 30 per cent. Many observers<sup>10</sup> have reported prompt improvement with roentgen therapy. A large percentage of the patients so treated become afebrile in from twelve to twenty four hours. Nightingale and Starr<sup>11</sup> in an experience with over 180 cases of erysipelas in children have obtained very encouraging results with ultra violet irradiation.

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## INFECTIOUS GANGRENE OF THE SKIN AND SUBCUTANEOUS TISSUES

Gangrene of the skin and subcutaneous tissues due to microorganisms may be either acute or chronic. The treatment of the various types differs markedly and a delay in diagnosis results in a delay in instituting the proper treatment. In the acute cases a diagnosis should be made within a few hours but in the chronic case a delay of no is may be safely made within a few days. The diagnosis in acute gangrene must frequently be made largely on the basis of clinical symptoms. In the chronic forms the clinical diagnosis must be fortified by careful bacteriologic studies.

### ACUTE GANGRENE

Acute infectious gangrene may be divided into two subgroups of great importance. These differ in so many features that they should not be confused. The first is relatively common namely gas gangrene. The second is relatively rare namely hemolytic streptococcus gangrene.

**Gas Gangrene**—Gas gangrene not infrequently develops in a deep punctured or lacerated wound which extends down into the muscle and carries with it such foreign bodies as clothing, missiles, powder or street dirt. It is therefore common in war wounds. A large proportion of the cases of gas gangrene in civil practice follow compound fractures. Occasionally it develops after the amputation of gangrenous lower extremities of a diabetic or arteriosclerotic patient.

**Symptoms**—The disease usually begins with an abrupt rise in temperature and pulse rate. There is general malaise, marked prostration and restlessness as well as apprehension. The pulse rate approaches 120 and the temperature 103° to 105° F. There is usually an increase of pain in the wound.

**Signs**—Examination of the wound usually reveals swelling and edema with redness and acute tenderness. The skin at the wound margin first becomes red, then dusky, then dark and necrotic while the reddened

area away from the margin takes on a yellowish brown or bronzed tint. If the disease spreads extensively in the muscle the gangrene of the skin margin slowly advances but it does not appear in isolated patches away from the margin. Gentle pressure on the margins of the wound will usually produce a sanguinopurulent exudate in which gas bubbles may be seen. A smear made from this exudate will almost invariably reveal numerous large gram positive bacilli. Gentle palpation of the tissues may reveal crepitus. This may not be appreciated in the early stages but after it appears it may advance appreciably from hour to hour. An x-ray film will frequently demonstrate gas in the tissues even before it can be felt. It may also be heard with a stethoscope. To an experienced observer with a keenly discriminating sense of smell there is a characteristic acid or mousey odor.

**Pathology**—The spread of the disease is chiefly in the muscles. It may be confined to a single muscle extending from the wound margin up to its origin leaving the neighboring muscles free but usually it spreads up the neighboring groups as well to a varying extent. The muscles become soft mushy and dark red and microscopic sections show fragmentation of the muscle fibers with gas bubbles, large numbers of gram positive bacilli and a paucity of fixed tissue or wandering cells. (See section on Bacteriology of Surgery.)

**Etiology**—There are four different species of spore-forming anaerobic bacilli of the gas gangrene group which are pathogenic for man and although they rarely occur in pure culture in gangrenous processes they are believed to be able alone to produce the general and local symptoms of gas gangrene and their specific toxins may cause death. The most common of the gas gangrene organisms is *Bacillus aerogenes capulatus* (*Clostridium welchii*). The others are *B. oedematiens* (*C. novyi*), *Vibrio septique* (*C. oedematis maligni* or *C. septicum*) and *B. mordellii* (*C. mordellii* or *C. oedematoides*).

Occasionally one sees an emphysematous infection in which none of the pathogenic spore-forming bacilli are found. In such cases smears of the exudate show only cocci and gram negative bacilli. Cultures yield anaerobic streptococci and either aerobic or

anaerobic gram negative bacilli. These infections generally spread much more slowly than do those due to gram positive bacilli.

**Treatment**—If the signs are unmistakable or if in doubtful cases large gram positive bacilli are numerous in the smear immediate operative intervention is of utmost importance. This procedure should not wait for the cultural determination of the organisms. The wound should be completely excised and all foreign bodies and necrotic tissue should be removed. Individual muscles should be explored and any inactive or devitalized muscle tissue removed. When all the involved muscle that can safely be removed surgically has been excised the wound should be flooded with a creamy suspension of sterile (Du Pont's medicinal grade) zinc peroxide (now distributed by both Merck and Mallinckrodt) in sterile distilled water and then packed lightly with gauze or absorbent cotton soaked in this material. This in turn is covered with a thick layer of cotton soaked in distilled water. The whole dressing is sealed with petrolatum gauze to prevent evaporation. This dressing should be changed daily until the anaerobic organisms have disappeared from the wound. If the disease is diagnosed soon after its development amputation usually is not indicated unless there is a compound fracture. Gas gangrene antiserum should be used in large quantities. Depending on the severity and extent of the infection two or more "therapeutic doses" should be given intravenously as soon as the diagnosis is made and repeated every eight hours until there is definite subsidence of local and general symptoms. If it is not possible to determine by culture what organisms are present a polyvalent serum should be used but if an analysis of the flora of the wound has been made more specific antiserum should be administered in subsequent treatments.

Recently favorable results have been reported from the use of roentgen therapy and also from sulfathiazole in cases of gas gangrene. One hundred roentgens to the affected area twice a day for three days is the advocated dose of x-rays. Sulfathiazole should be given in an initial dose of 4 Gm. and 1.5 Gm. every four hours thereafter until the infection is under control. Its value in these cases has not been clearly demonstrated as

yet. For the present, one would be justified in advocating these forms of treatment only in conjunction with adequate surgical treatment. Recently penicillin has been used with encouraging results but successfully only when given in huge doses of 50 000 or even 100 000 units every two or three hours.

**Hemolytic Streptococcus Gangrene.**—Since the author's first report in 1924 this infection has been described by several observers. This disease may occur following a deep wound but is more likely to follow a much more trivial injury such as a scratch cut or hypodermic injection. It generally occurs on the extremities but may involve any part of the body. In the earlier literature some of these cases were described as phlegmonous or gangrenous erysipelas but there are striking differences between the disease and erysipelas which will be brought out later.

**Symptoms.**—The disease is characterized by the sudden onset of pain and swelling at the site of the injury. The temperature generally does not rise to over  $101^{\circ}$  or  $102^{\circ}$  F except in rare instances when the illness is ushered in with a chill. Then the temperature may reach  $103^{\circ}$  or  $104^{\circ}$  F. On the other hand the pulse rate is rapid frequently approaching 120. Prostration is marked but instead of irritability there is usually marked lassitude. The patient becomes indifferent to his surroundings and has no appreciation of the severity of his illness.

**Signs.**—Within twenty-four hours the part becomes red, hot, swollen and heavy and while at first it may be very painful it later becomes numb or anesthetic. The redness spreads rapidly during the first two days and may be very marked but the margins fade out into the normal skin and are not raised as in erysipelas. *On the second, third or fourth day the pathognomonic sign of the disease appears. This should be watched for in any acute fulminating inflammation. The sign is a dusky coloring of the skin appearing in a small purplish patch with irregular and ill-defined margins. It may be some distance from the portal of entry. It has at first a bluish tinge which makes it distinct from the brilliant redness of the surrounding skin. At the same time a large blister or bulla may appear over this dusky area or somewhere else on the red surface. These*

areas may extend very rapidly and changes in them may be seen from hour to hour. In untreated patients about the seventh, eighth or ninth day if the patient survives this necrotic skin becomes more sharply demarcated from the rest of the skin and a little later partial separation takes place along the edges. Metastatic foci may develop in the lungs or joints or elsewhere in the body. Frequent sites for these metastatic lesions are the subcutaneous tissues usually without gangrene. In a few untreated patients the process may come to a standstill about the end of the second week and large plaques of necrotic subcutaneous fat may separate beneath a relatively normal skin. But as a rule if no treatment is given the case goes on to rapidly overwhelming toxemia with septicemia, extensive metastases and death.

**Pathology.**—This disease is essentially a gangrene of the subcutaneous tissue with secondary gangrene of a part of the overlying skin resulting from thrombosis of the skin arteries which pass through the sloughing subcutaneous fat. The subcutaneous gangrene may extend for a long distance beyond the area of skin gangrene but hardly ever extends down into the muscle or bone unless the original wound carries it to these depths. The blood culture is positive in about half of the cases.

**Etiology.**—The hemolytic streptococcus is always found on aerobic culture in these cases and in the great majority of cases it may be found in pure culture out in the advancing margin of the subcutaneous necrosis as well as in the blister or bullar fluid. Beyond the limit of the subcutaneous necrosis there is a zone of redness and edema which yields a sterile culture. Later when the gangrene separates other organisms may contaminate the field but usually do not spread widely. It is almost certain that these associated organisms play no part in the development of the disease and that it is in fact a pure hemolytic streptococcus infection. The rapidity of its development and the extensive necrosis which it causes suggest that the peculiar characteristics of the onset of the infection may be due to a hypersensitivity similar to the Schwartzman or to the Arthus phenomenon.

**Treatment.**—As soon as the diagnosis has

been made, penicillin should be given in doses varying from 20,000 to 30,000 units every three hours. Surgical treatment should not be delayed and the extent of the subsequent skin necrosis will be greatly increased. Contrary to the usual procedure either in erysip

TABLE 2—DIFFERENTIATION OF CASES OF ACUTE GANGRENE\*

Name	Etiology	Symptomatology	Pathology	Treatment
Gas gangrene	Deep wound into muscle. Gram positive spore forming anaerobic rods. Occasionally anaerobic streptococci in association with aerobic or anaerobic gram negative bacilli. Early development of various kinds of associated bacteria.	Sudden onset. Profound general symptoms. High fever, rapid pulse, apprehension, irritability. Relatively mild local signs. Limited redness, swelling and edema of skin. Crepitation. Dusky wound margins. Bronzing of skin. Limited gangrene.	Extensive death of muscle. Fibers broken by gas formation. May spread whole length of a single muscle. Exudate loaded with gram positive rods. Relatively few pus cells. Negative chemotaxis for leukocytes.	Prompt operation. Removal of all foreign bodies and dead tissue. Complete debridement of wound. Daily flooding of wound with a water suspension of Du Pont medicinal grade zinc peroxide. Early administration of large quantities of polyvalent or specific serum. Penicillin in large doses. X-rays. Sulfathiazole or sulfadiazine.
Hemolytic streptococcus gangrene	Superficial wound. Pure culture of hemolytic streptococcus. No other bacteria or late occurrence of a few other species after gangrenous skin has separated.	Sudden onset. Relatively mild general symptoms. Low fever but rapid pulse. Lassitude, indifference, somnolence. Alarming local signs. Extreme redness and edema with cut sharp margins. Irregular dusky areas on second, third or fourth day. Blisters and bullae. Rapidly developing extensive gangrene.	Extensive necrosis of subcutaneous tissues with a wide zone of sterile edema beyond the limits of necrosis. Heavy exudation of fluid and polymorphonuclears at first and later large mononuclear phagocytes. Bacteria found all through the necrotic subcutaneous fat and in the blisters and bullae. Thrombosis of some of blood vessels to overlying skin, which becomes gangrenous.	Prompt operation. Long incisions to the limits of the subcutaneous necrosis. Release of all tension. Removal of necrotic tissue as soon as possible with a minimum of flooding. Hot application of moist heat until subsidence of cellulitis. Then Dakin's solution to favor separation of the slough. Penicillin. Sulfanilamide or sulfadiazine. Skin grafting if defect is extensive.
Erysipelas	Superficial wound. Pure culture of hemolytic streptococcus. No associated bacteria.	Sudden onset. Profound general symptoms. Chills. High fever. Rapid pulse. Apprehension. Irritability. Slowly but steadily spreading area of redness with little or no swelling and edema. Fading in the center. Sharp raised margins.	Slight swelling and thickening of skin. No edema of subcutaneous fat. Bacteria in and beyond advancing zone and not in center of lesion.	No operation. Such as local application of ultraviolet light. Serum in severe cases. Sulfanilamide or sulfadiazine, if ultraviolet radiation is not used.

\* Melaney, Surg., Gynec. &amp; Obst. 37.

be delayed an hour after the diagnosis has been made. If it is delayed for twenty-four hours after the pathognomonic signs appear, the chances of recovery will be greatly diminished in streptococcus cellulitis of the ordinary kind. Longitudinal incisions should be made at once through the gangrenous area and should extend in both directions just be-

beyond the limits of the subcutaneous necrosis. The effect of these incisions is to relieve tension and to drain at least partially, the involved area. After operation hot water soaks or hot poultices should be used until the cellulitis subsides. This usually requires two or three days. Then Dakin's fluid should be applied by means of tubes or frequently changed compresses to favor the rapid separation of the slough. Each day as much of the slough as can be removed without bleeding should be cut away. Sulfanilamide by mouth in an initial dose of 6 Gm and 1 Gm every four hours thereafter should be given until the infection has come under complete control. Zinc peroxide is not effective in this condition because the extensive slough prevents adequate contact.

**Differential Diagnosis**—1. Ulminating types of gangrene fall either into the gas gangrene group or into the hemolytic streptococcus gangrene group. They should not be confused for in the former the injury is almost always deep and the invasion is largely in the muscular layers with gas formation and crepitation both in the muscles and in the subcutaneous tissues while the skin is relatively free. In hemolytic streptococcus gangrene on the other hand the injury is usually superficial and the spread is almost always in the subcutaneous tissues with early involvement of the skin and without any crepitation. In gas gangrene the general symptoms are alarming and the local signs relatively mild. In hemolytic streptococcus gangrene the local signs are alarming and the general symptoms relatively mild. While both infections are primarily due to specific organisms infection may be rendered more severe by the association of other bacteria. However in the case of gas gangrene these organisms generally gain a foothold at the same time or before the organisms of the gas gangrene group whereas with hemolytic streptococcus gangrene the hemolytic streptococcus is alone responsible for the initiation of the infection and secondary contaminants grow only after there has been a break at the margin of the gangrenous portion of the skin. Stained smears of the exudate in gas gangrene show many gram positive rods while in streptococcus gangrene the exudate contains only gram positive diplococci or short chains.

Hemolytic streptococcus gangrene has been frequently confused with erysipelas which is likewise caused by a hemolytic streptococcus but certain features sharply distinguish them. They may be differentiated by reference to table 2.

### CHRONIC GANGRENE

Cases of chronic infectious gangrene may be separated into four important subdivisions. While all of these groups are characterized by some distinctive clinical features it seems certain that in each type the characteristic lesions are produced not by one organism as in the acute cases but by a special combination of two or more organisms. These diseases may therefore be called synergistic infections. They may be conveniently named as follows: (1) postoperative progressive bacterial synergistic gangrene of the abdominal or chest wall; (2) gangrenous impetigo (ecthyma); (3) fusospirochetal infection of the skin and (4) amebic infection of the skin.

**Postoperative Progressive Bacterial Synergistic Gangrene**—One of the most striking examples of chronic gangrene of the skin is that which occasionally follows the drainage of an abscess either in the peritoneal cavity or in the chest.

**Symptoms**—In the majority of the cases which have been reported the gangrene has followed drainage of a peritoneal abscess. Usually there is very little general reaction manifested either by fever or anemia and the patient remains in fairly good general condition although as the process goes on he is gradually worn down with discouragement and pain. About the end of the first or second week after operation the patient and the doctor both realize that all is not well with the healing of the wound. *The whole region becomes exquisitely tender. This symptom is an outstanding feature of the disease.* At first the wound becomes red, swollen and tender. In a few days the wound margins or the stitch holes develop a carbuncular indurated necrotic appearance. The center of activity becomes purplish while the outer zone takes on a brilliant red. Within a few days the purplish areas widen and the part first affected becomes frankly gangrenous. The color of the dead skin changes to a dirty grayish brown and the

surface is dull like suede leather. The purple zone spreads outward into the red and as it does so the skin becomes raised above the normal skin level. The central side of the purple zone toward the gangrene is sharply defined but irregular and crented. On the outer side it fades off into the red zone and flattens to the level of the normal skin. The gangrenous skin remains firmly adherent to the purple zone and becomes undermined at its free margin but there is very little if any undermining of the normal skin. As the process advances the gangrenous skin liquefies on its inner margin leaving exposed a base of granulation which gradually enlarges.

**Etiology**—In most of the cases reported in the literature only routine bacteriologic studies were made but when careful anaerobic as well as aerobic methods are used a *microaerophilic non hemolytic streptococcus* may be found in pure culture at the periphery of the lesion not only in the red zone but occasionally just beyond it in the relatively normal tissues. In the gangrenous tissue itself this organism is found to be associated with a hemolytic *Staphylococcus aureus*. When the streptococcus or staphylococcus is injected in pure culture into animals no lesion is produced but when half doses of each organism are combined

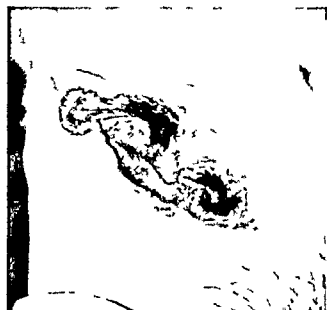


FIG. 31.—Typical progressive bacterial synergistic gangrene following ecchymia. Note the two areas starting around retention sutures. Entirely allent suede leather gangrene surrounded by raised purple zone with crented inner margin. Bright red zone on outer side facing off into normal skin.

**Pathology**—The lesion is essentially a necrosis of the skin. The destruction of the dermis is not always complete and here and there some deep islands of epithelium from sweat glands or hair follicles may start patches of regenerating skin. In the gangrenous zone all of the tissues are homogeneously necrotic and masses of cocci in clusters and chains may be found. In the purple zone there is edema and a dense infiltration with wandering cells. Here fewer organisms are present and they appear in diplo form and in short chains. In the red zone there is hyperemia and a few diplo cocci.

and injected a gangrenous process usually develops which will spread during the course of three or four days and simulate to a considerable degree the lesion in man. This has been repeatedly confirmed. With the demonstration that these organisms can do something together which they cannot do alone the theory has been advanced that the disease is the result of a synergistic action of the two organisms, the non hemolytic microaerophilic streptococcus being the essential organism in the zone of advance and in some way preparing the ground for the gangrenous action of the staphylococcus. The streptococcus is almost certain



derived from the intestinal tract while the staphylococcus may come from the patient's skin or from the air.

**Treatment**—In most of the reported cases the original wound was partially closed with 'tension' sutures. Such tissue tension in the presence of contamination may have favored the establishment of the infection. This suggests as a prophylactic measure that all skin wounds should be left unsutured when a peritoneal abscess, chronic empyema or lung abscess is drained. The chronicity of this condition has afforded the opportunity of trying to cure it by many methods. Certain of the reports reflect the ingenuity and persistence of surgeons in using all sorts of chemical and serologic agents both generally and locally in the face of a baffling problem. In almost every case conservative methods including local excision of the gangrenous margins have failed to check the advance of this process but radical removal of the lesion including the outer zone of redness either with the knife or with the cautery, has almost invariably resulted in prompt disappearance of the disease. Sterilized medicinal grade zinc peroxide suspended in distilled water and applied after the excision helps prevent a recurrence of the infection. Under its application granulations soon appear. The defect left by this radical operation may then very quickly be restored by skin grafting. Recently the author has treated two patients systemically with penicillin with prompt and complete subsidence of the inflammation spontaneous separation of the gangrenous margin and progressive healing without the necessity for wide excision.

**Gangrenous Impetigo (Ecthyma)**—For a good many years reports have appeared in the literature describing a chronic gangrenous disease of the skin appearing in undernourished persons both young and old who were generally in a low state of nutrition and were frequently suffering from recurrent attacks of dysentery. It has been given many names by dermatologists among them *ecthyma pyoderma gangrenosum*, *impetigo gangraenosa* and *dermatitis gangrenosa*.

**Symptoms**—There are very few symptoms with the onset of the infection. Crops of vesicles appear which soon become pus-

tulous and then frankly gangrenous. As they progress they become moderately or seriously painful and the patient is conscious of fever and malaise. This condition may last for months or years with exacerbations and remissions. Frequently a crop of small fresh gangrenous lesions may develop after a recurrence of diarrhea or colitis.

**Signs**—The lesions are usually multiple and show various stages of development, one lesion following another in rather rapid succession. They occur most frequently on the scalp face and abdomen but may be found on any part of the body. They generally start as small vesicles surrounded by a red zone. The center then becomes dark gangrenous and depressed. The lesion increases in size slightly and occasionally two or three neighboring lesions coalesce but even the coalesced lesions seldom measure more than 1 or 2 cm. in diameter. The disease is contagious and frequently occurs in several members of a family at the same time. Likewise the patient inoculates other areas of his body. As new lesions develop the old ones frequently dry, the necrotic skin comes off as a scab and a scar is left behind. The larger and deeper lesions however may persist for a long time. The gangrenous center then separates at the margin leaving a ring of depressed ulceration from the center of which the gangrenous plaque stands up like a button. If this separates from its base a clean ulcer is left which slowly heals.

**Pathology**—The necrosis is relatively superficial with a base of granulations infiltrated with wandering cells chiefly of the large mononuclear variety and with gram positive cocci in short chains and masses.

**Etiology**—The cause of this disease has been variously explained by different authors but several workers have regularly found a hemolytic streptococcus and a staphylococcus in the lesions and have attributed the disease to a synergistic action of these organisms. With these two organisms in combination similar lesions have been produced in animals while pure cultures of either failed to do so.

**Treatment**—Most authors believe that the majority of these patients will recover if general nutritional measures are instituted and if the usual methods of treating impetigo are continued industriously. Many cases

surface is dull like suede leather. The purple zone spreads outward into the red and as it does so the skin becomes raised above the normal skin level. The central side of the purple zone toward the gangrene is sharply defined but irregular and eroded. On the outer side it fades off into the red zone and flattens to the level of the normal skin. The gangrenous skin remains firmly adherent to the purple zone and becomes undermined at its free margin but there is very little if any undermining of the normal skin. As the process advances the gangrenous skin liquefies on its inner margin leaving exposed a base of granulation which gradually enlarges.

**Etiology**—In most of the cases reported in the literature only routine bacteriologic studies were made but when careful anaerobic as well as aerobic methods are used a *microaerophilic non hemolytic streptococcus* may be found in pure culture at the periphery of the lesion not only in the red zone but occasionally just beyond it in the relatively normal tissues. In the gangrenous tissue itself this organism is found to be associated with a hemolytic *Staphylococcus aureus*. When the streptococcus or staphylococcus is injected in pure culture into animals no lesion is produced but when half doses of each organism are combined

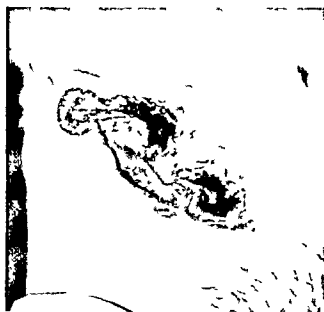


Fig. 31. Typical progressive bacterial synergistic gangrene following cercarial myiasis. Note the two areas situated around retentive cast of insect. Centrally a flaccid, suede-leather gangrene surrounded by raised purple zone with erosion of inner margin. Bright red zone extends to the free edge of gangrene into normal skin.

**Pathology**—The lesion is essentially a necrosis of the skin. The destruction of the dermis is not always complete and here and there some deep islands of epithelium from sweat glands or hair follicles may start patches of regenerating skin. In the gangrenous zone all of the tissues are homogeneously necrotic and masses of cocci in clusters and chains may be found. In the purple zone there is edema and a dense infiltration with wandering cells. Here fewer organisms are present and they appear in diploform and in short chains. In the red zone there is hyperemia and a few diplo-cocci.

and injected a gangrenous process usually develops which will spread during the course of three or four days and simulate to a considerable degree the lesion in man. This has been repeatedly confirmed. With the demonstration that these organisms can do something together which they cannot do alone the theory has been advanced that the disease is the result of a synergistic action of the two organisms, the non hemolytic microaerophilic streptococcus being the essential organism in the zone of advance and in some way preparing the ground for the gangrenous action of the staphylococcus. The streptococcus is almost certain

derived from the intestinal tract while the staphylococcus may come from the patient's skin or from the air.

**Treatment.**—In most of the reported cases the original wound was partially closed with 'tension' sutures. Such tissue tension in the presence of contamination may have favored the establishment of the infection. This suggests as a prophylactic measure that all skin wounds should be left unsutured when a purulent abscess, chronic empyema or lung abscess is drained. The chronicity of this condition has afforded the opportunity of trying to cure it by many methods. Certain of the reports reflect the ingenuity and persistence of surgeons in using all sorts of chemical and serologic agents both generally and locally in the face of a baffling problem. In almost every case conservative methods including local excision of the gangrenous margins have failed to check the advance of this process, but radical removal of the lesion including the outer zone of redness either with the knife or with the cautery, has almost invariably resulted in prompt disappearance of the disease. Sterilized medicinal grade zinc peroxide suspended in distilled water and applied after the excision helps prevent a recurrence of the infection. Under its application granulations soon appear. The defect left by this radical operation may then very quickly be restored by skin grafting. Recently the author has treated two patients systematically with penicillin with prompt and complete subsidence of the inflammation, spontaneous separation of the gangrenous margin and progressive healing without the necessity for wide excision.

**Gangrenous Impetigo (Ecthyma).**—For a good many years reports have appeared in the literature describing a chronic gangrenous disease of the skin appearing in undernourished persons, both young and old who were generally in a low state of nutrition and were frequently suffering from recurrent attacks of dysentery. It has been given many names by dermatologists among them *ecthyma pyoderma gangrenosum*, *impetigo gangrenosa* and *dermatitis gangrenosa*.

**Symptoms.**—There are very few symptoms with the onset of the infection. Crop of vesicles appear which soon become pu-

tulous and then frankly gangrenous. As they progress they become moderately or seriously painful and the patient is conscious of fever and malaise. This condition may last for months or years with exacerbations and remissions. Frequently a crop of small fresh gangrenous lesions may develop after a recurrence of diarrhea or colitis.

**Signs.**—The lesions are usually multiple and show various stages of development, one lesion following another in rather rapid succession. They occur most frequently on the scalp face and abdomen but may be found on any part of the body. They generally start as small vesicles surrounded by a red zone. The center then becomes dark, gangrenous and depressed. The lesion increases in size slightly, and occasionally two or three neighboring lesions coalesce but even the coalesced lesions seldom measure more than 1 or 2 cm. in diameter. The disease is contagious and frequently occurs in several members of a family at the same time. Likewise the patient inoculates other areas of his body. As new lesions develop, the old ones frequently dry, the necrotic skin comes off as a scab and a scar is left behind. The larger and deeper lesions, however, may persist for a long time. The gangrenous center then separates at the margin leaving a ring of depressed ulceration from the center of which the gangrenous plaque stands up like a button. If this separates from its base a clean ulcer is left which slowly heals.

**Pathology.**—The necrosis is relatively superficial with a base of granulations infiltrated with wandering cells, chiefly of the large mononuclear variety and with gran positive cocci in short chains and masses.

**Etiology.**—The cause of this disease has been variously explained by different authors but several workers have regularly found a hemolytic streptococcus and a staphylococcus in the lesions and have attributed the disease to a synergistic action of these organisms. With these two organisms in combination similar lesions have

derived from the intestinal tract while the staphylococcus may come from the patient's skin or from the air.

**Treatment**—In most of the reported cases the original wound was partially closed with 'tension' sutures. Such tension in the presence of contamination may have favored the establishment of the infection. This suggests as a prophylactic measure that all skin wounds should be left unsutured when a peritoneal abscess, chronic empyema or lung abscess is drained. The chronicity of this condition has afforded the opportunity of trying to cure it by many methods. Certain of the reports reflect the ingenuity and persistence of surgeons in using all sorts of chemical and serologic agents both generally and locally in the face of a baffling problem. In almost every case conservative methods including local excision of the gangrenous margins have failed to check the advance of this process but radical removal of the lesion including the outer zone of redness, either with the knife or with the cautery, has almost invariably resulted in prompt disappearance of the disease. Sterilized medicinal grade zinc peroxide suspended in distilled water and applied after the excision helps prevent a recurrence of the infection. Under its application granulations soon appear. The defect left by this radical operation may then very quickly be restored by skin grafting. Recently the author has treated two patients systemically with penicillin with prompt and complete subsidence of the inflammation, spontaneous separation of the gangrenous margin and progressive healing without the necessity for wide excision.

**Gangrenous Impetigo (Ecthyma)**—For a good many years reports have appeared in the literature describing a chronic gangrenous disease of the skin appearing in undernourished persons both young and old who were generally in a low state of nutrition and were frequently suffering from recurrent attacks of dysentery. It has been given many names by dermatologists among them *ecthyma pyoderma gangraenosum*, *impetigo gangraenosa* and *dermatitis gangraenosa*.

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**Etiology**—The cause of this disease has been variously explained by different authors but several workers have regularly found a hemolytic streptococcus and a staphylococcus in the lesions and have attributed the disease to a synergistic action of these organisms. With these two organisms in combination similar lesions have been produced in animals while pure cultures of either failed to do so.

**Treatment**—Most authors believe that the majority of these patients will recover if general nutritional measures are instituted and if the usual methods of treating impetigo are continued industriously. Many cases

picked with fine-mesh gauze or absorbent cotton soaked in the zinc peroxide suspension covered with a thick layer of cotton wet with distilled water and then sealed with petrolatum-impregnated gauze to prevent evaporation. This dressing should be changed daily until the infecting organisms have completely disappeared.

**Amebic Gangrene**—Amebic infection of the skin has been described by a number of authors practicing in regions in which amebic disease is common. In most of the cases which have been reported the involvement of the skin has been secondary to spontaneous or operative drainage of an hepatic abscess. A few cases of infection of the skin have followed some operative procedure on the large intestine. Two observers have described fistulas about the anus due to amebae. The author and his brother have described a lesion of the buttock and scrotum. Gangrenous lesions of the skin attributed to amebae which seemed to rise without any direct connection with an internal focus of the disease have been listed only twice in the recent literature.

**Symptoms**—In the cases in which a gangrenous lesion of the skin develops secondary to the drainage of a deeper focus there is always a period of days or weeks during which there is no specific change in the wound. Then the drainage tract becomes red, swollen and painful in a manner similar to that in many drained wounds. Fever is not a prominent feature in these cases.

**Signs**—The edges of the wounds become indurated, everted and raised above the surrounding skin which takes on a dark brown color with hyperpigmentation. As the necrosis spreads the center of the lesion remains as an ulcerated surface covered with dark granulations having "a color resembling that of raw beef which has been exposed to the air for some time" (Heimberger). The surface is covered with foul smelling exudate of thick brownish, blood tinged pus with shreds of necrotic tissue in it.

**Pathology**—Usually the chief involvement is in the skin and subcutaneous tissue but the muscle may be involved in which case the whole wound becomes necrotic for a considerable depth. In amebic lesions which have no connection with a deep focus

the infection with amebae apparently must be preceded by an established infection with other organisms. This at once suggests the possibility of a symbiotic rather than a specific action. In such a case the infection remains relatively superficial. The spread seems to be in the cutis while the epidermis is involved secondarily and gives way. Glutinous pus in small droplets may be expressed from the margin of the ulceration. This is said to be quite characteristic of the infection. Amebae may be found in the advancing zone of gangrene.

**Etiology**—In only one of all the cases reported reviewed by the writer have careful anaerobic as well as aerobic bacteriologic studies been mentioned. The bacterial factor either alone or in symbiosis with the amebae may not have been given the attention which it deserves but in the author's case such studies were made and the conclusion was drawn that amebae may be the essential factor in the production of this type of lesion. It seems to the writer that one or all of the following conditions should obtain before it can be fairly stated that amebae are participating actively in any infection: (1) there should be histologic evidence of the invasion of the tissues by the amebae; (2) they should be found either by smear or culture in the advancing margin of the lesion or (3) the lesion should respond to medical treatment recognized as adequate for amebic disease. The writer believes that the mere presence of amebae on the surface of the lesion or in the exudate is no more evidence of their participation in the infection than the presence of *B. coli*, *B. proteus*, *C. welchii* or any of the other intestinal organisms is evidence of their activity in the tissues about a fecal fistula.

**Treatment**—In all cases of amebic abscess of the liver, the possibility of skin necrosis after drainage must be kept in mind and precautions taken to avoid it. An attempt should be made to protect the skin wound at the time of operation. A two stage procedure might increase wound resistance to the infection. If a one stage operation is performed there should be complete relaxation of the wound with no attempt to close the skin and subcutaneous tissues by suture. If pathogenic amebae have been found, emetin hydrochloride should be given intra-

synergistic group there is no history of amebic infection or evidence of a deep amebic lesion; no amebae are found either in the stools or in the exudate from the lesion or in the tissues and there is no response to antamebic treatment. In the amebic cases there is frequently a history of previous amebic dysentery or a frank deep amebic lesion. Amebae are frequently found in the stools as well as in the exudate from the wound and in the tissues and the lesions may respond promptly, often surprisingly, to emetin and antyodim treatment. In bacterial synergistic gangrene the lesion is extensive but superficial and develops slowly. It does not invade the muscle and the base of the ulcerated center is composed of active granulations which frequently reveal isolated islands of regenerating epithelium. In the amebic infections the lesion is usually deeper; it develops more rapidly and it may involve the muscle. The granulations have a raw beef appearance and islands of regenerating epithelium are rare. Pressure on the margins produces glairy pus in which the amebae may be found. All the lesions of progressive bacterial synergistic gangrene which have been cultured both aerobically and anaerobically at the time of excision have yielded a microaerophilic non-hemolytic streptococcus in pure culture in the spreading periphery of the lesion while cultures in the zone of gangrene have revealed this organism in association with others. As far as the writer is aware the advancing margin of the amebic lesions has been examined bacteriologically only once and the microaerophilic non-hemolytic streptococcus was not found.

Gingivous impetigo and fusospirochetal gangrene of the skin are more easily differentiated. The differentiation of the types of chronic infectious gangrene may be conveniently summarized in chart form (Table 3).

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## INDOLENT ULCERS

(See also Section on *Ulcers* and *Plastic Surgery*)

Indolent ulcers are chronic necrotizing lesions with fairly regular contour and with rounded edges without undermining of the skin. The base of the ulcer is grayish yellow and sometimes purplish red and from it exudes a seropurulent material having a characteristic foul odor. These ulcers are most often situated on the lower part of the leg or around the malleoli and are usually surrounded by discolored and indurated skin. They tend to grow larger rather than to heal spontaneously.

Under this classification are considered the following kinds of indolent ulcers: (a) varicose ulcers, (b) ischemic ulcers, (c) trophic ulcers, (d) infectious ulcers and (e) Marjolin's ulcers.

## VARICOSE ULCERS

Diseases of the central nervous system such as syringomyelia, transverse myelitis, tumors or injuries of the spinal cord or peripheral nerve disturbances such as neuritis, leprosy, injuries or tumors of nerves and other neurotrophic disturbances are predisposing factors to the development of indolent ulcers on the extremities.

The disturbance in the nervous system must be recognized and the nature of the lesion accurately determined in order that specific medical or surgical treatment can be instituted in addition to the local care of the indolent ulcer. Protection of the extremities from further trauma is vitally important.

**Treatment.—General Measures.**—All predisposing factors must be sought for and eliminated as completely as possible. Diabetes, if present, must be kept controlled at all times by diet alone or by diet and insulin according to the needs of the individual patient. A well balanced diet with an adequate intake of vitamins is essential. Patients with severe secondary anemia should be given at least one unit of freshly drawn whole blood by transfusion before active treatment of the indolent ulcer is started. Varicose veins should be obliterated by ligation or by the use of sclerosing solutions (sodium morrhuate or soricoin) but only after all signs of local inflammation about the indolent ulcer have disappeared.

Local warmth (50° to 90° F) is beneficial and hastens the healing of indolent ulcers but the application of uncontrolled heat through the use of a cradle with electric bulbs, an electric heating pad or any other mechanical or electrical heating device is absolutely contraindicated. Such uncontrolled heat increases the local metabolism of tissues and augments the need for oxygen without producing a proportional increase in the supply of arterial blood because of the structural changes in the local blood vessels.

Indolent ulcers should be cleansed frequently with warm water. The affected extremity should be elevated above the level of the heart until the edema has disappeared. This requires several days of complete bed rest. Gauze compresses moistened with warm saline solution should be applied every two hours during the day as long as

the patient is confined to bed. This procedure removes all dried secretions from the ulcer and stimulates the growth of healthy granulation tissue at its base.

Areas of chronic necrosis should be kept dry to inhibit growth of bacteria. Antiseptic powders are much less efficient drying agents than are the aqueous solutions of mercuriochrome or tannic acid (Latimer). The frequent application of 5 per cent aqueous solution of mercuriochrome to these areas will cause the necrotic tissue to mummify. Such sterile scabs or eschars must not be forcibly removed. Spontaneous separation of the eschar can be hastened by meticulous care of the skin of the part and by stimulating the local arterial circulation through active and passive vascular exercises. Several weeks or even months may be required for complete separation of the eschar but as long as no infection is present they cause no harm to the host.

When the patient is ambulatory it is essential to provide adequate support to the tissues of the affected extremity. The supportive dressing described by Gordon is satisfactory. A piece of old linen covered with the desired medicament should be applied directly on the ulcer and covered with a small gauze pad or thin rubber sponge so that uniform but gentle pressure is exerted on the ulcer at all times. The tissues of the entire lower part of the leg should be supported by an elastic bandage (no. 8 Ace bandage 2½ inches wide) or by a properly fitted elastic stocking. Such support should be worn whenever the patient is up and about but must be removed when he goes to bed.

The length of time needed to heal a chronic or indolent ulcer varies according to its size, the local condition of the tissues, the nature of the predisposing causes and the general health of the patient. Many indolent ulcers of the extremities are refractory to all forms of palliative treatment.

**Surgical Measures.**—Surgical debridement of necrotic tissue in an indolent ulcer must be done with great care lest more harm than good result from the procedure. Chemical debridement through the careful use of freshly prepared Dakin's solution on small gauze compresses applied directly to the base of the ulcer is a safer means of remov-

ing necrotic tissue. An ulcer which has dense scar tissue at the base or is surrounded by scar tissue can frequently be cured permanently by wide and deep excision which leaves only normal tissue at the base. The defect can be covered immediately or at some later time with an Ollier Thiersch type of skin graft.

Analysis of the results following surgical or chemical interruption of the sympathetic innervation to the extremity which is the site of an indolent ulcer has shown that the procedure causes the ulcer to heal quickly but that it rarely remains healed. Palliative measures should always be given a fair trial.

### INFECTIOUS ULCERS

Infection is the most frequent exciting factor in the production of indolent ulcers. Practically all ulcers become contaminated with a variety of micro organisms. The bacterial flora of an indolent ulcer usually determines its chronicity and since the advent of sulfonamides and penicillin the specific therapy also depends upon the kind of bacteria present.

Chronic ulceration of the skin due to bacterial synergism has been demonstrated by Meleney. The chronic undermining ulcer caused by the microaerophilic streptococci also presents a characteristic clinical picture. Meleney has shown that activated zinc peroxide used locally and the sulfonamides given in adequate amounts by mouth offer a satisfactory means of controlling this serious variety of infectious ulcer. An ointment containing zinc and calcium peroxides as introduced by Altmeier is much simpler to use and more effective than the zinc peroxide paste for eradicating the microaerophilic bacteria from indolent ulcers.

Specific infections with spirochetes as in syphilis and yaws and with acid fast bacilli as in tuberculosis and leprosy also give rise to chronic ulcers on the extremities. Systemic diseases of these types must always be considered in the differential diagnosis of indolent ulcers for there is nothing absolutely pathognomonic for any of these lesions. Syphilis and yaws tend to produce punched out ulcers on the extremities while the edges of the indolent ulcers associated with tuberculosis and leprosy tend to be indurated and even undermined. A mixed

bacterial infection is usually present and the local appearance of the ulcer is frequently determined by the kind and the virulence of the invading micro organisms. Specific treatment when it is available must always be given in addition to the local care of the ulcers.

Recently Thompson has presented evidence to show that fungus infection between the toes is a factor in the production of chronic ulceration on the lower part of the leg. It is important to eradicate all traces of epidermophyton infection from the feet of a patient with an indolent ulcer. The tissues of the lower part of the leg have been shown to become highly sensitized to the toxins of the fungi and bacteria. The clinical condition of recurrent cellulitis of the extremities which frequently complicates indolent ulcers may be accounted for on such a basis. The use of autogenous vaccines to desensitize these patients has proved successful in stopping the recurrent attacks of cellulitis. The indolent ulcer then responds to local treatment.

### MARJOLIN'S ULCERS

An indolent ulcer which has been present for many years may suddenly undergo cellular changes which convert the innocent ulcer into a lesion which endangers the life



Fig 31—Marjolin's ulcer. Squamous cell carcinoma has developed at the edges of an indolent ulcer of many years standing. Note the irregularity of the raised border of the ulcer. Sixteen years after amputation together with surgical removal of the inguinal lymph glands was performed.

of the patient. The epithelial cells at the margin of the ulcer begin to grow wildly as a result of the constant irritation from exudates, medicaments or infection and from the continued attempts of the skin to cover



the ulcer by epithelial proliferation and growth. Such malignant degeneration of an indolent ulcer is called Marjolin's ulcer (Fig 34). Whenever the edge of an ulcer is raised or appears rolled, biopsy of the tissue should be made and the nature of the cellular changes determined. If malignant changes have taken place in the epithelial cells, it is important to ascertain the exact cell type and the grade of activity of the epithelioma so that definitive treatment can be instituted without further delay. These epitheliomas usually do not extend below the superficial layer of the deep fascia of the leg. As they spread by way of the lymphatic pathways, it becomes important to remove completely the regional lymphatic glands by surgical operation as soon as the malignant nature of the lesion is definitely established. These tumors are very resistant to radiation therapy.

In the early stage of a Marjolin ulcer it is possible to remove the lesion completely by widely excising the skin and underlying fascia. The defect can be covered by a split thickness skin graft. When the epithelioma is far advanced, the only hope for permanent cure lies in amputation of the part with complete removal of all the regional lymph glands.

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#### CHRONIC UNDERMINING ULCER

In 1935 a chronically progressive ulceration of the skin was described as a clinical and bacteriologic entity. It is fortunately rare but is of importance because of the extent of its involvement of the surface of the body, because of its stubborn resistance to the usual forms of treatment and because of the frequently fatal outcome.

**Clinical Course.**—The disease begins gradually in the vicinity of an incised infected lymph gland in an operative wound associated with the intestinal or the genital

tract or in an accidental wound. The lymph gland group occurs in the neck, axilla or groin. The postoperative type generally follows an operation on the intestine, appendix or genital tract. The third type may occur anywhere on the body surface.

What appears to be an ordinary infection fails to follow the usual course of healing. Improvement which may have been present in the early stages gradually ceases. The skin margins slowly become undermined with liquefaction of the subcutaneous fat and connective tissue and inversion of the margins. There is no gangrene of the skin, but as the undermining progresses, areas in the neighboring skin may take on a dull red or bluish appearance. It is then found that the undermining has extended beneath these areas and the skin has been thinned out as if it were being liquefied from beneath. After a number of weeks a small opening generally appears in these thin areas. These secondary openings gradually enlarge and may extend until they fuse with the original ulcer, or they may leave a bridge of skin in between which becomes epithelialized on its deep surface. In lower abdominal lesions the undermining frequently spreads down toward the groin or toward the pubic region, extending into the vulva, into the scrotum or beneath the crease of the groin into the thigh. In these regions it may burrow deeply, dissecting beneath the muscles and forming deep sinuses into the pelvis. In certain places where the skin is more firmly attached to the deep tissues, such as around the umbilicus or the crest of the ilium, the undermining may stop. Sometimes there are portions of the margin where undermining does not take place and healing may proceed with a new growth of skin. Then instead of progressing steadily, the margin of the new epithelium may suddenly stop advancing, or may rapidly melt away. Occasionally these ulcers develop on the leg after a minor injury. In such cases there is always some undermining of the skin margins, but usually they do not undermine extensively in this region.

Pain is usually moderate but may be excruciating. Fever may rise to 101° and 103° F. daily for a long time or may swing to lower levels. During the period of fever the patient is usually greatly prostrated. In the

course of time the lack of response to treatment frequently brings great discouragement and gradually breaks down the patient's morale. This may reach such a degree that the patient expresses a desire to commit suicide. After months or years of suppuration the lesion may gradually heal spontaneously but if improper treatment is given it usually burrows deeply and causes death either by erosion of a large vessel or by the gradual development of amyloid degeneration of the liver, spleen and kidneys.

**Etiology**—The essential organism in this infection is a hemolytic streptococcus which prefers an anaerobic environment. Its immediate source is probably either the intestinal tract or the vagina. In many cases it can be obtained only by anaerobic cultiva-

tive treatment however and one that will almost always effect a cure provided the medication can be applied to every part of the wound. This is the daily use of medicinal grade zinc peroxide produced by the Dupont Chemical Company and distributed by Merck and Mallinckrodt which is a white powder containing about 50 per cent of  $ZnO$  and lesser proportions of  $ZnCO_3$  and  $Zn(OH)_2$ . The active ingredient here is the zinc peroxide which provides a very highly oxygenated environment which at first inhibits and then actually kills the organisms in the lesion or modifies their cultural characteristics to such an extent that the infection almost at once ceases to advance and starts to retrogress. The powder—which must be the medicinal grade ac-



Fig. 3a.—Chronic undermining ulcer involving pelvis and thigh with deep sinus formation and daughter ulcers with sacral resection and thigh. Note the extensive undermining and cribriform openings in the skin with bridges between *Vol. gangrene*

tion and is therefore frequently missed with the routine aerobic methods. From some lesions it may be obtained aerobically but it can almost always be demonstrated to grow better anaerobically than aerobically. The organism undoubtedly belongs to the group of anaerobes by predilection of Prevot although he did not describe any hemolytic varieties. The term microaerophilic seems to be preferable.

**Treatment**—Practically every known form of general and local medication and physical modality has been tried in these cases. There has been some evidence of improvement with the use of maggots and there has been at least one spontaneous recovery (after twenty-six months following the use of ultraviolet light). The most effec-

tively generating oxygen when suspended in sterile distilled water—should be sterilized in small quantities in a dry sterilizer at  $140^{\circ}C$  for four hours and suspended in its own volume of sterile distilled water just before use. This gives an even creamy suspension which may be applied with the aid of a syringe and catheter to all parts of the ulcerated surface and sinuses. It is essential that the medicine reach every nook and cranny of the infected area for the lesion may spread in any region which is not reached. Any unapproachable regions should be opened widely. The ulcerated portion should be covered with fine-mesh gauze or absorbent cotton soaked in the suspension of zinc peroxide. This in turn is covered with a layer of cotton soaked in distilled water. The whole

region should then be sealed with gauze impregnated with petrolatum or ZnO ointment to prevent evaporation. After twenty-four hours the dressing comes away easily without sticking to the wound. The whole wound should be irrigated with sterile saline solution or distilled water and a fresh suspension applied. When the undermined flaps have become sealed down skin grafts may be applied to cover over the remaining defect.

Sulfanilamide should also be given if the patient can tolerate it. In many cases there is hypersensitivity to this drug. In some of the simpler cases this drug alone may effect a cure but a combination of sulfanilamide by mouth if tolerated with zinc peroxide locally will result in the most rapid healing. Recently in a number of these cases penicillin has been used without benefit.

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## CYSTS OF THE SKIN AND MUCOUS MEMBRANE

**Definition**—A cyst is a cavity either natural or newly formed filled with material which is more or less fluid or pulsatous and surrounded by an investing membrane or capsule which separates it from the surrounding tissues. Cysts of the skin and mucous membrane may be classed as either retention or extravasation cysts. Retention cysts occur as the result of a blocking of the normal outlet. Extravasation cysts are encapsulated collections of fluid not in a pre-existing cavity.

**General Considerations**—The majority of all cysts occur about the head and neck where they are unsightly. The removal of all such cysts is to be recommended because

some are likely to become actively infected and suppurate and others though rarely may undergo malignant changes.<sup>14</sup>

Much care should be exercised in removing cysts. If during extirpation of such a tumor a remnant of its lining is left within the wound the growth will probably recur. Consequently the old method of transfixing the cyst expelling its contents and pulling away its lining membrane is usually unsatisfactory. Excision of a tumor when acutely inflamed is strictly contraindicated.<sup>14</sup>

#### SEBACEOUS CYSTS

(*Atheroma Atheromatous Cyst Pseudo Atheroma Retention Cyst Sebaceous Tumor Steatoma Wen*)

**Definition**—A sebaceous cyst is a cystically dilated sebaceous gland.

**Etiology**—The cause is obstruction or obliteration of the excretory duct of the gland with retention of its secretions. The obstruction may be due to inspissated glandular secretion or to some extraneous cause. Obliteration of the duct may also be a sequel of inflammation of the gland or may possibly be congenital or traumatic. There is some evidence that a tendency to develop sebaceous cysts may be inherited.

**Pathology**—A sebaceous cyst has an outer fibrous wall and an inner wall of squamous epithelium representing the secreting cells of the gland. The contents are cheesy more rarely fluid they consist of sebum fatty epithelial cells and cholesterol crystals and usually give off a rancid odor.

**Symptomatology**—Unless there are complications the only symptom is the presence of a rounded painless swelling on the skin with loss of overlying hair when the cyst is located on the scalp. Frequent complications are inflammation and suppuration of the cyst with ulceration of the overlying skin. A rare complication is malignant degeneration.

the body characteristically in great numbers wherever there is lanugo. They are small sebaceous tumors varying in size from that of a millet seed to that of a cherry.<sup>11</sup> These swellings often show a black speck at the apex representing the blocked mouth of the duct otherwise the overlying skin is not discolored unless inflamed. The swelling is doughy or slightly elastic on touch and is easily movable in relation to the underlying structures but the skin is not movable over it. It is of very slow growth. Usually a rancid odor of the contents when it is opened is a point of diagnostic importance.

**Prognosis**—The prognosis is favorable unless the cyst has undergone malignant change. The development of carcinoma on

cyst does not return. Even after carcinomatous change recurrence after complete removal of the tumor is rare and metastasis is infrequent.

**Treatment**—Sebaceous cysts are easily removed under local anesthesia. The overlying skin is first divided, the incision being made to correspond with the natural folds of the part. Any redundancy of the skin may be removed with the tumor by an elliptical incision. The sac should be removed intact if possible. If it is ruptured all fragments must be found and removed to insure against recurrence or the development of a fistula. Malignant cysts require a liberal incision through healthy tissue on all sides. A malignant tumor should never be cut into during its removal.<sup>1</sup>

### DERMOID CYSTS

(Cuticular Cyst Embryoma Inclusion Cyst Piloerous Cyst Sequestration Cyst)

**Definition**—A dermoid cyst is a benign congenital cyst arising from displaced epithelium and containing derivatives of both epiblast and mesoblast.

**Etiology**—It arises from the infolding of a skin rudiment in the closure of an embryonic fissure or from other displacement of epithelium in the developmental period.<sup>9</sup>

**Pathology**—The cyst is unilocular with a capsule and with the wall showing the skin structure more or less complete with the strata in reversed order, the horny layer being innermost. One or more of the dermal appendages (sebaceous glands, sweat glands and hair follicles) are present. The cyst contains an odorless thick liquid or cheesy mass either whitish or yellowish composed of disintegrated epidermal cells, cholesterol crystals, sebum and frequently lanugo. A dermoid cyst may contain teeth, hair and bone and may shade over into a teratoma.

**Symptomatology**—On the skin the only symptom is the presence of a smooth rounded painless tumor usually small and unobtrusive. On the floor of the mouth a dermoid may displace the tongue upward and backward, give a nasal quality to the voice or even make speech indistinct; it may interfere with respiration, deglutition and mastication or produce enlargement of the submental region and even prognathism.



Fig. 36—Large sebaceous cyst over left eye

a sebaceous cyst base is generally considered rare but the subject should not be dismissed without calling attention to this possibility. Schwalbe reviewed the literature in 1914 and found 43 cases of sebaceous cysts in which carcinoma had developed in the cyst walls. In a more recent report among 236 cases at the Mayo Clinic, Callor<sup>2</sup> found 12 (or 344 per cent) in which carcinoma occurred. Bishop<sup>4</sup> of the Steiner Cancer Clinic in Atlanta in a review of 119 cases found carcinoma in 9.2 per cent. Stone and Abbey of the New York Post Graduate Medical School and Hospital reported in 1915 in a series of 693 cases of sebaceous cysts an incidence of carcinoma of 2.2 per cent. If the sac is entirely removed the

**Diagnosis**—Although congenital a dermoid cyst frequently does not manifest itself until adult life. It is found most often at the site of an embryonic fissure or channel and in the midline. It is not usually freely movable, being attached at the base to the deep fissure, but the skin is normally movable over it. To touch it may be soft and doughy or elastic and fluctuant. Through the mucous membrane it has a whitish appearance. The most frequent site of a dermoid cyst of the mucous membrane is the floor of the mouth. Here it may be *sublingual* lying between the genioglossal and genio-glossal muscles or *submental* separated from the mouth cavity by the genioglossal muscle. A submental dermoid does not follow the movements of deglutition. Roentgen examination may help in the diagnosis if the cyst contains opaque material. The final diagnosis is made on the finding of dermal appendages in the cyst wall and sebum and epidermal derivatives in the contents. Dermoid cysts contain one or more derivatives of the dermis such as hair, teeth and sebaceous material. Dermoids in the floor of the mouth or in the submental and submaxillary regions must be distinguished from ranulas, cystic hygromas, cysts of the thyroglossal duct, chronic suppurative infections of the submaxillary salivary gland, branchial cysts, lipomas and neurofibromas. The one notable feature which distinguishes a dermoid in these regions from the before mentioned conditions is its *patty like or doughy feeling on palpation*.<sup>15</sup>

**Prognosis**—For dermoid cysts of the skin and mucous membrane the prognosis is favorable if no complications arise. The cyst will not return if the sac is wholly removed. Malignant degeneration (carcinomatous and sarcomatous) occurs occasionally with or without metastasis. It occurs in 19 per cent of the cases of dermoid of the breast. The presence of a round circumscribed subcutaneous lesion of the breast should be suspected as being a dermoid cyst and as potentially malignant. Transillumination may help clinically in distinguishing a cyst from a solid mass.<sup>12</sup>

**Treatment**—Complete extirpation is the operation of choice. It is important to remove the entire cyst wall. Local field block with 1 per cent novocain is very satisfac-

tory. The incision should follow the natural lines of the skin of the area involved. A dermoid of the floor of the mouth if small may be removed through the mouth if large through an incision parallel to the lower border of the mandible with care not to endanger Wharton's ducts.<sup>2</sup> When a dermoid cyst is adherent to the bone the periosteal attachment must be removed along with the tumor. Also any cordlike extensions should be removed to effect a cure. When an external sinus is present the incision should include an elliptic portion of the skin around the sinus which facilitates the removal of the tract.<sup>11</sup>

### EPIDERMOID CYSTS

(*Epithelial Cyst, Implantation Cyst, Post-traumatic Cyst*)

**Definition**—An epidermoid cyst is a benign cyst arising from displaced epidermic cells.

**Etiology**—The generally accepted theory is that an epidermoid cyst is traumatic in origin and arises from a fragment of epidermis torn off and driven into the deeper tissues in the course of an injury. For this reason it is often called a traumatic epithelial cyst of the skin.<sup>3</sup>

**Pathology**—The cyst is unilocular and may or may not have a fibrous capsule. The cyst wall shows the epidermal structure more or less complete with the strata in reversed order the horny layer being innermost. Dermal structures are absent. The contents are a whitish or grayish cheesy mass made up of disintegrated epidermal cells.

**Symptomatology**—The only symptom unless the cyst suppurates or makes pressure on surrounding structures is the presence of a smooth rounded painless tumor under the skin.

**Diagnosis**—Rarely have epidermoid cysts been diagnosed as such but they constitute an important skin lesion that may have annoying and occasionally serious complications. It is significant to note that this topic has been given little if any space in textbooks.<sup>16</sup>

The most frequent sites are the palms of the hands, the flexor surfaces of the fingers and the toes, next in frequency are the fore-

the body, characteristically in great numbers wherever there is lanugo. They are small sebaceous tumors varying in size from that of a millet seed to that of a cherry.<sup>11</sup> These swellings often show a black speck at the apex representing the blocked mouth of the duct; otherwise the overlying skin is not discolored unless inflamed. The swelling is doughy or slightly elastic on touch and is easily movable in relation to the underlying structures, but the skin is not movable over it. It is of very slow growth. Usually a rancid odor of the contents when it is opened is a point of diagnostic importance.

**Prognosis.**—The prognosis is favorable unless the cyst has undergone malignant change. The development of carcinoma on

cyst does not return. Even after carcinomatous change, recurrence after complete removal of the tumor is rare and metastasis is infrequent.

**Treatment.**—Sebaceous cysts are easily removed under local anesthesia. The overlying skin is first divided, the incision being made to correspond with the natural folds of the part. Any redundancy of the skin may be removed with the tumor by an elliptical incision. The sac should be removed intact if possible. If it is ruptured, all fragments must be found and removed to insure against recurrence or the development of a fistula. Malignant cysts require a liberal incision through healthy tissue on all sides. A malignant tumor should never be cut into during its removal.<sup>1</sup>

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**Etiology.**—It arises from the infolding of a skin rudiment in the closure of an embryonic fissure or from other displacement of epithelium in the developmental period.<sup>2</sup>

**Pathology.**—The cyst is unilocular with a capsule and with the wall showing the skin structure more or less complete with the strata in reversed order, the horny layer being innermost. One or more of the dermal appendages (sebaceous glands, sweat gland and hair follicles) are present. The cyst contains an odorless, thick, liquid or cheesy mass, either whitish or yellowish, composed of disintegrated epidermal cells, cholesterol crystals, sebum and frequently lanugo. A dermoid cyst may contain teeth, hair and bone and may shade over into a teratoma.

**Symptomatology.**—On the skin the only symptom is the presence of a smooth, rounded, painless tumor, usually small and unobtrusive. On the floor of the mouth a dermoid may displace the tongue upward and backward, give a nasal quality to the voice or even make speech indistinct; it may interfere with respiration, deglutition and mastication or produce enlargement of the submental region and even prognathism.



Fig. 36.—Large sebaceous cyst over left eye.

**Diagnosis**—Although congenital a dermoid cyst frequently does not manifest itself until adult life. It is found most often at the site of an embryonic fissure or channel and in the midline. It is not usually freely movable, being attached at the base to the deep fascia, but the skin is normally movable over it. To touch it may be soft and doughy or elastic and fluctuant. Through the mucous membrane it has a whitish appearance. The most frequent site of a dermoid cyst of the mucous membrane is the floor of the mouth. Here it may be *sublingual*, lying between the geniohyoid and genio-glossal muscles, or *submental*, separated from the mouth cavity by the geniohyoid muscle. A *submental dermoid* does not follow the movements of deglutition. Roentgen examination may help in the diagnosis if the cyst contains opaque material. The final diagnosis is made on the finding of dermal appendages in the cyst wall and sebaceous and epidermal derivatives in the contents. Dermoid cysts contain one or more derivatives of the dermis, such as hair, teeth and sebaceous material. Dermoids in the floor of the mouth or in the submental and submaxillary regions must be distinguished from ranulas, cystic hygromas, cysts of the thyroglossal duct, chronic suppurative infections of the submaxillary salivary gland, branchial cysts, lipomas and neurofibromas. The one notable feature which distinguishes a dermoid in these regions from the before mentioned conditions is its putty like or doughy feeling on palpation.<sup>15</sup>

**Prognosis**—In dermoid cysts of the skin and mucous membrane the prognosis is favorable if no complications arise. The cyst will not return if the site is wholly removed. Malignant degeneration (carcinomatous and sarcomatous) occurs occasionally with or without metastasis. It occurs in 10 per cent of the cases of dermoid of the breast. The presence of a round circumscribed subcutaneous lesion of the breast should be suspected as being a dermoid cyst and as potentially malignant. Transillumination may help clinically in distinguishing a cyst from a solid mass.<sup>12</sup>

**Treatment**—Complete extirpation is the operation of choice. It is important to remove the entire cyst wall. Local field block with 1 per cent novocain is very satisfac-

tory. The incision should follow the natural lines of the skin of the area involved. A dermoid of the floor of the mouth if small may be removed through the mouth if large, through an incision parallel to the lower border of the mandible with care not to endanger Wharton's ducts. When a dermoid cyst is adherent to the bone the periosteal attachment must be removed along with the tumor. Also any cordlike extensions should be removed to effect a cure. When an external sinus is present the incision should include an elliptic portion of the skin around the sinus which facilitates the removal of the tract.<sup>11</sup>

### EPIDERMOID CYSTS

(*Epithelial Cyst*, *Implantation Cyst*, *Post-traumatic Cyst*)

**Definition**—An epidermoid cyst is a benign cyst arising from displaced epidermic cells.

**Etiology**—The generally accepted theory is that an epidermoid cyst is traumatic in origin and arises from a fragment of epidermis torn off and driven into the deeper tissues in the course of an injury. For this reason it is often called a traumatic epithelial cyst of the skin.

**Pathology**—The cyst is unilocular and may or may not have a fibrous capsule. The cyst wall shows the epidermal structure more or less complete with the strata in reversed order, the *horvix* layer being innermost. Dermal structures are absent. The contents are a whitish or grayish cheesy mass made up of disintegrated epidermal cells.

**Symptomatology**—The only symptom unless the cyst suppurates or makes pressure on surrounding structures is the presence of a smooth rounded painless tumor under the skin.

**Diagnosis**—Rarely have epidermoid cysts been diagnosed as such but they constitute an important skin lesion that may have annoying and occasionally serious complications. It is significant to note that this topic has been given little if any space in textbooks.<sup>16</sup>

The most frequent sites are the palms of the hands, the flexor surfaces of the fingers and the forearm in frequency are the fore-

head and vertex.<sup>3</sup> The cyst is found most often in laborers exposed to injury. A history of injury is not always obtainable since a slight trauma may have been the causative factor and may have occurred years before the manifestation of the cyst. The cyst is freely movable and the overlying skin is unattached and normal in color. It is differentiated from a dermoid cyst which it otherwise resembles by the absence of dermal structures and the presence of epidermoid cellular structures. It is differentiated from a sebaceous cyst though the contents are similar in gross appearance by not having the intense sour odor often associated with sebaceous material. Epidermoid cysts rarely become malignant and seldom become infected. If incompletely removed they tend to recur. An epidermoid cyst on the pulp of the thumb or finger may erode into the phalanx.<sup>6 10</sup>

**Prognosis**—The prognosis is favorable unless malignant changes which are rare occur.

**Treatment**—Radical extirpation before infection has supervened is the ideal treatment. The postoperative reaction is slight.

### MUCOUS CYSTS

#### (Retention Cyst)

**Definition**—A mucous cyst is a cystically dilated mucous gland.

**Etiology**—Inflammation of the gland or traumatism of the orifice of the duct may cause occlusion or obliteration of the excretory duct with retention of the glandular secretions.

**Pathology**—The cyst may be unilocular or multilocular. The wall is thin and of glandular structure and may be embedded in the surrounding muscular tissue. The contents are a glairy mucus.

**Symptomatology**—The only symptom is the presence of a painless bluish somewhat translucent protuberance on the mucous membrane.

**Diagnosis**—A mucous cyst may occur singly or multiple cysts may develop on the mucous surfaces of the lips and cheeks floor of the mouth border of the tongue and vulva. They present rounded tense fairly movable tumors darker in color than the surrounding mucous membrane and varying

in size from that of a pea to that of a hazel nut always being larger when occurring in the floor of the mouth. Their growth is slow.

A rare condition lately described by Gross is that of recurring myxomatous cutaneous cysts of the fingers and toes which is believed to be a myxomatous degeneration of the derma resulting in a peculiar mucoid change in the connective tissue of the corium this process leading to liquefaction and cyst formation. This type of cyst is apparently not connected with the joint bursa or tendon sheath a puzzling pathogenesis. It occurs as a small thin walled cyst on the dorsal aspect of the finger or toe and contains a colorless odorless thin or gelatinous fluid. It is refractory to surgical treatment recurring repeatedly after excision. The best results are secured from x-ray or radium therapy.<sup>12</sup>

**Prognosis**—The prognosis is favorable. Malignant change is unknown or extremely rare.

**Treatment**—Cure is usually effected by the removal of the wall of the cyst. Occasionally it will be wise to cauterize the cavity with the cautious use of an electric crutery.

### BLOOD CYSTS

(*Extravasation Cyst Hematocyst Hemorrhagic Cyst Blood Blister Hemangioma Vascular Nevus*)

**Definition**—As indicated by the synonyms three different pathologic entities found in the skin and mucous membrane pass under the name of blood cysts. The first is an exudative cyst containing degenerated blood. The second is a cyst of a blood vessel familiarly called a blood blister and appearing usually on the tongue or lip. The third is a blood lake developing in a neoplasm composed of proliferated or hypertrophied blood vessels. (See section on Angioma in the chapter on the Vascular System.)

**Etiology**—The exudative cyst arises from a bruise with hemorrhage into the subcutaneous tissues forming a hematoma which for some reason fails to become absorbed liquefies and becomes walled in by reactive fibrosis. The blood blister type of cyst has its origin in a varix. The blood



lake' in the congenital vascular tumor is produced by the breaking down of the endothelial elements

**Pathology**—The exudative or extravasation blood cyst has a thick fibrous wall showing hematoïdin crystals in its inner layers. The content is a clear yellow serum. The pathology of the other types of blood cysts mentioned is sufficiently indicated by their definition and etiology.

**Symptomatology**—Usually the only symptom is the presence of a small tumor generally bluish in color but reddish or purplish if on the mucous membrane. If the tumor is deeply situated the skin is not discolored. A cavernous hemangioma or nevus may be very disfiguring.



Fig. 37—Hemangioma (blood cyst) of the tongue. This tumor gradually became larger over a period of fifteen years. (Courtesy of Dr. B. Shelnire.)

**Diagnosis**—The diagnosis should not be difficult to make from their appearance alone. If there is doubt it is usually safe to explore a cyst with an aspirating needle. Of the blood cysts found in the mouth or on the inner surface of the lips of infants Shelnire writes: 'In addition to this type in infants more complex familial and hereditary vascular tumors may be encountered in the oral vestibule in association with similar tumors on the cutaneous surface and deep blood cysts of the neck.'

**Prognosis**—The prognosis is favorable. There is no fixed tendency to malignant growth or to recurrences when a cyst is removed surgically or treated with radium.

**Treatment**—The treatment of choice is complete surgical extirpation or exposure to radium therapy, especially the gamma rays. Radium will perhaps give the best cosmetic results. In the treatment of hemangioma of the oral cavity Shelnire<sup>10</sup> has obtained gratifying results, particularly in adults by the following method:

An ordinary hypodermic syringe is filled with a 5 per cent solution of sodium morrhuate. The needle is inserted into the cyst and the sodium morrhuate injected until slight distention of the cyst is felt. The needle is then withdrawn and if possible pressure is applied with the finger tips about the cyst to prevent rapid outflow of the injected solution. Moderate pain and swelling of the part follow within a few hours. When properly injected the cyst then has a brown indurated feel. From two to four injections are required to obliterate the average oral blood cyst.<sup>10</sup> In hemangiomas characterized by extensive metastasis a malignant process may have developed (hemangio-sarcoma) and should be treated radically.

Dentigerous cysts and ranulas are discussed elsewhere.

I. MICHAEL HOLDEN

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## NEOPLASMS OF THE SKIN

Neoplasms of the skin can be divided into benign and malignant forms although a sharp distinction between the two may in some cases be impossible either on clinical or histopathologic findings. Only the more common neoplasms especially those requiring surgical treatment will be described here.\* Lesions of the mucous membranes including leukoplakia and epithelioma are omitted. Various types of foreign body tumors such as paraffinomas and xanthoma pyogenicum molluscum contagiosum and the verrucae are omitted because they each have an infectious or inflammatory basis. Also various types of xanthomas which have to do with disturbances of metabolism of lipoids. It is important to examine the skin of the entire body as more than one type of cutaneous neoplasm often may be present.

### BENIGN NEOPLASMS

Benign neoplasms of the skin include (1) *fibromas* such as single or multiple nodules of dermatofibroma lenticulare (subdermal fibrosis) and multiple pedunculated flaccid and pigmented lesions of neurofibromatosis (von Recklinghausen's disease) (2) *keloids* which are hypertrophic elevated scars either spontaneous or secondary to trauma (3) *neuromas* (4) *lipomas* including adiposis dolorosa (Dercum's disease) (5) *hemangiomas* which are of varying size and depth from the cavernous type to the spider nevus and port wine mark (6) *lymphangiomas* either diffuse or circumscribed often with features of a lymphangiolymphangioma (7) *myomas* which are divided into dartle myoma and leiomyoma (8) *chondromas* (9) *osteomas* (10) *dermoids* (11) *rare benign epithelial neoplasms* such as epithelioma adenoides cysticum (Brooke) cylindroma adenoma sebaceum (Pringle)

\* For a detailed description of different types of neoplasms see the references listed at the end of this section and textbooks on dermatology.

syngangoma and syngangoeutadenoma which do not suggest malignancy clinically although they resemble basal cell epithelioma histologically and (12) *nevi* including the ordinary pigmented mole which may be solitary or multiple and may vary greatly in size and the so called epithelial nevi of which verruca senilis (seborrheic keratosis) is the most common.

Etiologically the benign neoplasm is probably best explained as the result of *Misbildung* (malformation) of the tissue during fetal or postfetal life or as an embryonic rest except chondroma and osteoma which may be attributed to local or generalized metabolic disturbances and keloids and dermatofibroma lenticulare which may result from trauma.

Any benign neoplasm may as the result of repeated trauma or inadequate treatment eventually undergo malignant change although except pigmented nevi the incidence is very low.

**Treatment**—None of the conditions just mentioned requires surgical treatment except (1) when the neoplasm is situated in an area subject to trauma or irritation (2) when there is pain such as with some lesions of neurofibromatosis or leiomyomas and (3) when cosmetic results are desired as in the case of nevi of various types. Partial removal of pigmented nevi by caustics, fulguration, diathermy or superficial excision ignoring the fact that the roots usually extend to the depth of the hair follicle may frequently lead to malignant melanomas. Keloids may recur following excision in spite of associated radiotherapy. Plastic surgery is indicated in certain cases of superficial angioma especially of the port wine type if the lesion does not respond to radiotherapy, carbon dioxide snow or electrical methods. Benign epidermal neoplasms are relatively resistant to radiotherapy because of their slow growth and when their removal is indicated they should be excised surgically or removed by electrical method.

### MALIGNANT NEOPLASMS

Malignant neoplasms of the skin include (1) *epitheliomas* (2) *sarcomas* (3) *lymphoblastomas* (4) rare cases of *endothelioma cutis* and (5) *metastatic lesions* of the skin from neoplasms elsewhere in the body. The

etiology is the same as for cancer elsewhere and remains unknown. Trauma; exposure to actinic rays, including sunlight and radiotherapy; occupation, as in cases of tar cancer; heredity, as in cases of xeroderma pigmentosum, and the Irish or Chetaigne type of skin may be contributory factors. When there is doubt regarding the clinical diagnosis, a specimen for biopsy may be taken without danger of dissemination of the process except in cases of melanoma and Paget's disease of the nipple, in both of which frozen sections should be made at the time of operation. Malignant neoplasms usually occur in the later decades of life, but occasionally they are seen even in childhood.

predominates on the anterior portions of the face and forehead, but it may be found anywhere on the body. Histopathologically, there are strands or a lattice network, or glandular arrangement, or combinations of them, or a solid growth of basal-like cells arising from the basal cells of the epidermis and occasionally from the basal cells of the dermal appendages (Fig. 39, a). Extensive local destruction may result, involving cartilage and bone; when metastasis occurs, however, histologic examination will reveal a transition to a basal-squamous or squamous cell epithelioma. Occasionally, marked deposits of melanin pigment are seen in and between the cells of the tumor. Basal cell



Fig. 39.—a, Senile keratosis with resulting epithelioma; b, squamous cell epithelioma, grade I of the face; c, superficial epitheliomatosis showing thread-like border and varying size of lesions on the back; d, melanocarcinoma.

**Epithelioma** (some prefer the term carcinoma) (Fig. 38 a) includes basal cell epithelioma (*Basalzellenkrebs* or rodent ulcer), basal-squamous cell epithelioma, squamous (prickle) cell epithelioma (Fig. 38, b), and melanoepithelioma (Fig. 38, d) with or without pigment. There are also rare instances of true carcinoma of the dermal appendages or cutaneous metastasis of carcinoma from other organs of the body.

**Basal cell epithelioma** is a small or large, chronic, slowly progressing, superficial or deep nodule or ulcer, with a rolled, pearly, telangiectatic border, the center of which is usually covered with a crust, removal of which causes bleeding. This type of lesion

epitheliomas may be treated successfully in the great majority of cases by radiotherapy, by excision or by various electrical methods. Roentgen or radium therapy is probably the method of choice in cases of small epitheliomas about the eyelids and canthi. The physician should use the method or combination of methods with which he has become most familiar. Twenty per cent of the neoplasms diagnosed clinically as basal cell epitheliomas prove on microscopic examination to be basal squamous or squamous cell epitheliomas. They should be excised widely and deeply because both are relatively resistant to radiotherapy; in addition, the basal squamous type tends to infiltrate the

tissue at the margins in narrow strands of cells without becoming manifest clinically.

*Superficial epitheliomatosis* (benign erythematoid epithelioma) is characterized by single or multiple lesions (Fig 38 c) that vary in size from a few millimeters to 12 cm or more. These lesions predominate on the trunk and simulate ordinary basal cell epitheliomas except that they have a minute fine thread like border in which case they usually are basal cell epitheliomas when they are eczematoid in character they are basal squamous or squamous cell epitheliomas. Both types of superficial epitheliomatosis are usually resistant to radiotherapy and because of their situation are best treated by surgical excision. Usually skin

cent of cases. Statistics should be based on at least a five year period of observation. Lesions of grades 3 and 4 may lack the clinical features of ordinary epitheliomas and may require histologic differentiation from sarcoma, endothelioma or even benign ulcers. Squamous cell epithelioma of the lip must be distinguished from lesions of primary or tertiary syphilis. Squamous cell epitheliomas of grades 1 and 2 should be radically removed by excision or diathermy and when indicated such treatment should be followed after a year's interval by skin grafts of various types if the condition has not recurred. Metastasis to adjacent lymph nodes usually results in cases in which lesions are of grades 3 and 4 so that the prognosis

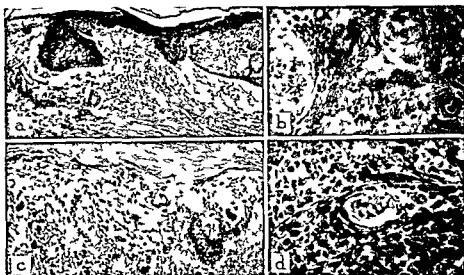


Fig 39—*a* Basal cell epithelioma *b* squamous cell epithelioma, grade 1 *c* Bowen's disease (epithelioma in situ) *d* squamous cell epithelioma, grade 3

grafting is not necessary because of the laxness of the skin. Superficial epitheliomatosis is frequently confused with benign dermatoses such as lupus erythematosus, psoriasis or tinea circinata.

*Squamous cell epitheliomas* present as a rule a wider and more indurated border than basal cell epitheliomas. They frequently arise from senile keratoses. Histologically they are graded 1 to 4 by Broders depending on the amount of differentiation of the individual cell, mitosis and pearl formation (Fig 39 *b* and *d*). He found that squamous cell epitheliomas of grade 1 recurred following excision in only 10 per cent of cases whereas for those of grade 4 successful results were obtained in only 10 per

cent of cases. Statistics should be based on at least a five year period of observation. Lesions of grades 3 and 4 may lack the clinical features of ordinary epitheliomas and may require histologic differentiation from sarcoma, endothelioma or even benign ulcers. Squamous cell epithelioma of the lip must be distinguished from lesions of primary or tertiary syphilis. Squamous cell epitheliomas of grades 1 and 2 should be radically removed by excision or diathermy and when indicated such treatment should be followed after a year's interval by skin grafts of various types if the condition has not recurred. Metastasis to adjacent lymph nodes usually results in cases in which lesions are of grades 3 and 4 so that the prognosis

*Melanocarcinomas* including melanotic whitlows are characterized by a deep steel blue color with or without radiating lines along lymphatic structures. They frequently develop from small superficial flat deeply

pigmented nevus which have been subject to repeated irritation trauma infection or in complete removal. They should be excised widely in the hope that glandular metastasis and pigmented or non pigmented metastasis elsewhere have not already occurred histologically. If there is evidence of invasion of the lymphatics by the tumor cells the prognosis is serious. When there is evidence of metastasis palliative roentgen therapy is of value in making the patient more comfortable and retarding the progress of the disease but death usually results within a couple of years although exceptionally patients have been known to live for a decade or more after dissemination has occurred. Melanocarcinoma must be distinguished from lesions of subdermal fibrosis with hemorrhage and nevus blau (blue nevus), neither of which presents radiating lines along lymphatic structures. In a blue nevus there usually is the history of onset in early childhood of a blue or blue gray papule or nodule which remains as such throughout life without increase in size. The blue nevus rarely as the result of repeated trauma may become a melanocarcinoma.

The so called precancerous dermatoses should be confined to Bowen's disease to senile arsenic, roentgen ray or radium keratoses to experimental or occupational cancer and to xeroderma pigmentosum. In approximately 20 per cent of the cases studied malignant epitheliomatous change occurs. In cases of xeroderma pigmentosum the epithelioma is usually basal cell in character in all the other conditions mentioned it is usually squamous cell. In the beginning there is an epithelioma *in situ* associated with various phenomena of individual cell keratinization dyskeratosis mitotic and amitotic division of cells and clumping of cells and formation of giant epithelial cells (Fig. 39 c). Rarely as the result of chronic irritation trauma or radiotherapy or even independent of the factors does malignant change develop in benign dermatoses such as lupus erythematosus lupus vulgaris syphilis ulcers sebaceous cyst calcified or not and even psoriasis and lichen planus.

Senile keratoses are to be sharply distinguished from verruca senilis the latter being benign and characterized by a verrucous greasy crust that is readily removed by friction

in contrast to the adherent keratotic crust of senile keratosis or cutaneous horn. Epitheliomas presumably precipitated by arsenic may occur on the trunk and simulate lesions of superficial epitheliomatosis but clinically they present verrucous keratotic crusted lesions and histologically are usually squamous cell epitheliomas of grades 2 to 4 with individual cell keratinization. All of these conditions call for surgical excision cauterization or diathermy. Radiotherapy is contraindicated.

Paget's disease of the nipple is characterized clinically by a persistent sharply circumscribed eczematoid lesion and histologically by the pale-staining Paget cells which are without apparent attachment to adjacent epithelial cells. The writer believes that the lesion of Paget's disease is a peculiar type of epithelioma *in situ* and that there is multicentric origin of the Paget cells from the epidermis and the epithelium of the dermal appendages including the lactiferous ducts. Muir has emphasized the origin of all Paget cells from the lactiferous ducts. In 75 per cent or more of the cases Paget's disease is associated with an underlying carcinoma of the breast so that complete or radical excision of the breast and adjacent lymph nodes is indicated.

Confusion arises among general pathologists and others regarding the differentiation of pseudo epitheliomatous hyperplasia as seen especially in bromoderma ichthyoderma blastomyces verrucous forms of cutaneous tuberculosis in the borders of chronic leg ulcers and in the tertiary syphiloderms. Familiarity with the histologic changes encountered in the diseases is essential. Marked and deep proliferation of the epidermal ridges even though irregular in outline may be distinguished from true epithelioma by the relative lack of mitotic figures the regular arrangement of cells and the invasion of the infiltrate into epidermal tissue.

Lymphoblastoma includes mycosis fungoides which usually begins primarily in the skin and presents indurated plaques of varying size with gyrate borders and the Erythema nodosum disease and lymphosarcoma which may occur primarily in the skin but are usually the result of metastasis or of extension from within lymphoblast

toma may appear as discrete or grouped nodules, plaques, or even ulcers and require histologic, clinical and hematologic study before a diagnosis can be made. In many cases exfoliative dermatitis is a manifestation of lymphoblastoma as is also toxic pruritus. Histologically mycosis fungoides reveals an infiltrate composed of a multiplicity of cell types, pyknosis and karyorrhexis and clumping of individual cells in the later stages there are many mitotic figures often going over into a lymphosarcoma thus justifying the inclusion of this condition with neoplastic diseases. The histopathologic picture of the leukemias, Hodgkin's disease and lymphosarcoma is similar to that seen in the glands or internal organs

in the case of dermatofibrosarcoma even a pedunculated adherent mass. Kaposi's disease usually starts with involvement of the extremities in the form of hemorrhagic pigmented plaques and nodules and probably is a disease of the reticuloendothelial system which eventuates in true sarcomatous change. Sarcomas vary in their degree of malignancy and should be widely excised before metastasis occurs. The other conditions especially lymphoblastoma and the Kaposi type of sarcoma call for palliative treatment with rad therapy.

It is important therefore from the standpoint of diagnosis, prognosis and treatment to differentiate carefully between the various benign and malignant neoplasms of the



Fig. 40—*a* The cutaneous picture was that of mycosis fungoides but blood studies showed lymphatic leukemia and biopsy of a lymph node showed lymphosarcoma. *b* Dermatofibrosarcoma. *c* Sarcoma of Kaposi.

The same holds true for metastatic cutaneous lesions of epithelioma, carcinoma (including carcinoma *en cuirasse* from metastasis from the breast) and sarcoma occurring elsewhere, all of which may present hard, slowly subcutaneous nodules which in the beginning often are not attached to the epidermis.

Primary sarcomas of the skin including the multiple idiopathic hemorrhagic sarcoma of Kaposi, the dermatofibrosarcoma of Darier, so-called endothelioma cutis and the so-called Spiegler-Fendly sarcoma (probably a lymphosarcoma) are uncommon skin lesions. These lesions may occur anywhere on the body, they may be single or multiple and they may appear as nodules or plaque or

skin. When in doubt one should resort to a specimen for biopsy or a dermatologic opinion or both.

HAMILTON MONTGOMERY

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## VI MILITARY SURGERY\*

### FOREWORD

This summary of the principles of military surgery is based on the experience of the surgeons of the North African Theater of Operations during the Tunisian Campaign (II Corps) the Campaign in Sicily (7th Army) the Italian Campaign (5th Army) and the Invasion of Southern France (7th Army). Both the 15th Strategic and the 12th Tactical Air Force have been based in this theater. Warfare in the air has spanned the periods of supremacy, decline and disappearance of the *Luftwaffe*.

In this period of nearly two years of active combat the Allied Forces have undertaken five large scale landing operations—North Africa, Sicily, Salerno, Anzio and Southern France. Ground operations have included combat in mountains and river valleys in deserts and rich cultivated fields in large cities and sparsely settled wilderness. Climatic conditions during two summers and winters have exposed the wounded to desert heat and mountain snow, to the siroccos of Africa that parch the lips and to the rainy season of the Italian peninsula with flooded rivers and deep mud. Hence the observations recorded and the conclusions drawn are presented as valid for *this geographical region only* and for *the conditions that prevailed during these two years*.

War is an unending series of specialized situations. In planning only the broadest principles are useful. Directives and experience can only inform the military surgeon his judgment as an individual at the time and place of an emergency must direct his action.

It is of great importance to recognize the ways that surgery in war may differ from the surgery familiar to civilian life and the reasons that underlie these differences. Only basic principles can be of value in future planning as it is certain that progress in civilian surgery will draw a new baseline of technical procedures before there is need to formulate details in any future war.

MAJOR GENERAL MORRISON C STAYER USA

### THE SCOPE AND NATURE OF MILITARY SURGERY

#### GENERAL CONSIDERATIONS

The care of the wounded must always be shaped by conditions and circumstances that stem from the exigent nature of war. Even the technical procedures of military surgery are found to differ radically from those of civilian surgery. To understand the

reasons for a departure from principles that appear firmly established by civilian experience it is important to know about some of the conditions that influence surgery in the field. The general impression that surgery in war is entirely molded by concessions to the need for haste and the confusion of caring for overwhelming numbers of patients is erroneous. Military surgery is not to be regarded as a crude departure from accepted

\* The source material on which this resume of military surgery is based is the current experience of the surgeons of the Mediterranean Theater. Supporting data are still largely in the form of official reports and only an insignificant portion has been prepared for publication. Assignment of credit where credit is due must await the appearance of articles in the periodical literature under the names of the individual surgeons who have voluntarily allied the task of compiling clinical reports to the labor of the actual care of the wounded. Meanwhile I can only express my indebtedness to the surgeons of the theater in offering a preview of their work to the present and future students.

Quantitative expressions of incidence, mortality, etc. have been introduced as percentage values without qualification. This makes for conciseness in contrast to a constant repetition of definite terms such as "about," "approximately," "roughly," and so on. As repeated reference is made to the difficulties that attend exact quantitative statements it is assumed that the designated values will not be taken too literally. When used they are based on analyses of representative samples of significant size and of random selection. They are subject to correction as the total mass of experience is subjected to systematic analysis. Actual numbers can not be given for security reasons.—EDC



surgical standards—'an awful business' as it has been called but as a development of the science of surgery to carry out a specialized and highly significant mission. To keep this development sound in the midst of war, when emotional forces so commonly displace scientific motivation is the prime challenge to the military surgeon.

Military surgery is the surgery of trauma encountered in epidemic proportions. Its scope is that of a surgical specialty—the management of wounds and injuries. As a result diagnostic problems are likely to be simple and treatment is immediate and direct. The patients of the military surgeon are young and previously healthy adult males conditioned to a uniform environment and displaying a standard behavior pattern. As a consequence surgical procedures become subject to standardization and a degree of control that at times may irk the surgeon accustomed to the individualistic practice of civilian life.

The violence of the trauma encountered in war with its consequent results on the human body far exceeds that usually encountered in civilian accidents. It is a common error for civilian surgeons to underestimate the destructive nature of flying missiles.

The large number of wounded who require treatment during periods of active combat demands quick decision, efficient organizational teamwork and a time-saving simplification of techniques.

Soldiers wounded in combat must be recovered from remote and oftentimes well-nigh inaccessible positions that are under fire. This introduces a time lag between wounding and surgical treatment that in most instances far exceeds the time lag between injury and treatment in civilian accidents. The lag will vary according to the terrain, the intensity of fire and other uncontrollable factors. It is rarely under four hours in land operations and may be prolonged to several days.

Even after a wounded man is transported by litter and ambulance to a hospital where surgical treatment can be undertaken, evacuation farther to the rear is necessary as soon as his condition permits. The movements of mobile hospitals to keep pace with the front and the necessity of keeping beds

open for newly wounded vary with the tactical situation and may be urgent and unpredictable.

Facilities for surgical treatment are adequate but necessity demands that they be simple and standardized. The ingenuity of the surgeon is challenged by the necessity to improvise and change his techniques to meet trying situations.

Modern surgical treatment employs many adjuncts to operative techniques that are of inestimable value when used correctly. Chemotherapy, fluid replacement therapy, transfusion of whole blood and the various fractions of blood employed as substitutes, potent anesthetic agents and narcotics are tools that are as important to the military surgeon as his scalpel but equally dangerous to the patient if used without expert precision. To make full use of these and similar measures and at the same time to avoid the dangers that attend their usage is one of the major responsibilities of the surgeon in the forward area.

**Phases of Surgical Management.**—The ever present necessity for evacuation to the rear divides technical surgical management into first aid measures, initial wound surgery, reparative wound surgery, reconstructive surgery and rehabilitation measures. These phases of surgical management of an individual patient are commonly telescoped in civilian practice into treatment by a single surgeon in one hospital. In time of war they must be strung out across the surface of the globe in a dozen or more hospitals and carried out by as many different surgeons. Surgical procedures must be properly placed in time and space with due regard to the tactical situation on the one hand and to the welfare of the patient on the other.

Unless a surgeon visualizes his position and the function of his hospital in relation to other surgeons and other hospitals he may become confused in the mission he is to carry out. Although he may perform some needed operation correctly, he is likely to impede the military effort and in addition may do unforeseen harm to a patient if he does an operation at the wrong time or in the wrong place.

**The Echelons of Surgery.**—The phases of surgical treatment listed above coincide in general with military echelons just as

the placement of the various types of hospitals and consequently the provision of facilities for surgical treatment are determined by the geographic deployment of a military force

**First Aid Measures**—Within the divisional area surgical management is limited to first aid measures and resuscitation. The wounded are transported by hand litter or jeep to the Aid Station and by litter and ambulance to the Collecting Station and the Clearing Station. Hemorrhage is controlled, splints and dressings are applied, morphia is administered for pain and reconstituted plasma is infused for resuscitation. In addition a booster dose of tetanus toxoid is given and chemotherapy with sulfonamides is initiated if desired.

Wounded men who die in this area are classified as Killed in Action (KIA). Approximately 90 per cent of those killed in action die immediately or at least are not seen alive even by an aid man. The 10 per cent that are seen alive before death usually have severe and multiple wounds (18 wounds per individual) with a predominance of head wounds (20 per cent). About one third of those seen alive die within an hour of being hit. Under these circumstances it is apparent that any attempt to carry surgical treatment above the level of first aid measures in this area would be futile even were it physically possible.

**Initial Surgery**—At the Divisional Clearing Station the wounded in action (WIA) are sorted into two categories—those that require initial surgical treatment at that point and those that may safely be transported farther to the rear still however to receive their treatment in the Army area.

Situated immediately adjacent to the Clearing Station is a small (50 bed) mobile surgical hospital. This is the farthest point forward at which initial surgical treatment can be properly done. Here certain essentials can be assured: a group of experienced surgeons, anesthetists and operating room personnel, simple but adequate operating room facilities, accommodation of the patients under shelter, nursing care and most important facilities to retain the more seriously wounded for a week or ten days.

Surgical treatment at this point is confined to a small group of wounded who re-

quire treatment for (1) correction of profound physiologic disturbances that immediately endanger life or (2) arrest or prevention of the complication of infection that if allowed to develop or progress may endanger life or lead to grave disability.

In the first category are placed casualties requiring control of continuing hemorrhage, restoration of an adequate effective blood volume, correction of mechanical disturbances of the cardiorespiratory system that directly cripple the functions of the heart and lungs and relief of pressure effects of craniocerebral wounds that threaten the continued function of vital centers. From the clinical standpoint these casualties include (a) continuing hemorrhage uncontrollable by first aid measures, (b) severe shock or hemorrhage, (c) sucking chest wounds or chest injuries producing respiratory distress, (d) head injuries with increased intracranial pressure and (e) maxillofacial wounds with respiratory obstruction.

The second category is subject to indefinite extension from a theoretical point of view; practically it is limited to casualties requiring control of the most fulminating infections of warfare—peritonitis and clostridial myositis (gas gangrene). From the clinical standpoint these casualties include (a) abdominal wounds, (b) suspected gas gangrene, (c) wounds of extremities with impairment of blood supply or those necessitating evacuation of the patient with tourniquet in place, (d) compound fractures of long bones and (e) wounds with extensive muscle damage.

By far the greatest number of wounded are transported five to ten miles farther to the rear to the Evacuation Hospitals. Here initial surgical treatment is carried out and the patient kept until fit for transportation to the base by ambulance, hospital tram, hospital ship or airplane ambulance. Employment of air evacuation for wounded before initial surgical treatment is not usual for wherever an advanced landing strip can be established, facilities also can be provided for surgical treatment prior to evacuation. Evacuation by air is an extremely important aid to the surgical management of the wounded; it is a swift and easy method of spanning hundreds of miles of terrain in which roads and rails have been

demolished or are crowded with the transport of supplies

**Reparative Surgery**—The general hospitals at the base receive wounded from the hospitals of the forward area for further surgical management. As the initial wound operation is by definition a limited procedure in nearly every case further treatment is required. Soft part wounds purposely left unsutured at the initial operation as a safeguard against infection are closed by suture usually at the time of the first dressing on or after the fourth day. Fractures are accurately reduced and immobilized until bony union takes place. Other procedures designed to prevent or combat wound infection are carried out to shorten convalescence and hasten return to duty or to prepare the wounded for transfer to the Zone of the Interior with minimal disability and deformity.

**Reconstructive Surgery**—In the Zone of the Interior the facilities of large general hospitals are directed toward final reconstructive surgery. Corrective operations, plastic operations, nerve suture and the fitting of prosthetic appliances are examples of the work that remains to be completed.

**Reconditioning**—In conjunction with corrective surgical treatment and remedial physiotherapy the final step in the rehabilitation of the wounded soldier is to prepare him for return to duty or for discharge to a useful position in civilian life. General physical training, vocational training and educational and orientation courses are directed toward complete physical and mental rehabilitation.

**The Lightly Wounded and Disposition to Duty**—Approximately half of those wounded in action who are admitted to hospitals may be classified as lightly wounded. These soldiers require prompt and expert treatment so they may return to combat duty at the earliest possible moment. This service is provided in evacuation hospitals and transfer is made to a convalescent hospital in the Army area from which each soldier is returned directly to his outfit. Those that require a longer period of recovery than can be provided in the Army area are evacuated to the Base to rejoin their organizations at a later date or be discharged to a replacement center. Approx-

imately 22.0 per cent of those admitted to hospitals return to duty without transfer out of the Army area. 10.2 per cent return to duty from the Base (10 per cent go to non-combat duty). 35.0 per cent are evacuated to the Zone of the Interior and 2.9 per cent die. If hospital admissions from injury and disease are included the salvage for duty is much higher—approximately 92 per cent.

**Statistics of Military Surgery**—Evaluation of a numerical expression of morbidity or mortality rates in military surgery requires complete information regarding the derivation of the figures and precise definition of the terms employed. It is impossible to overemphasize this point particularly when an attempt is made to compare the results of the treatment of wounded in one war with those of another or in one theater of operations as contrasted with a different theater or even to compare the results of successive campaigns or battles within the same theater.

The term *battle casualty* is defined in a specified manner for administrative records. Thus the percentage distribution of battle casualties in a certain campaign were:

	Per cent
Killed in action	15.5
Wounded	60.5
Missing	22.5
Died (in hospital)	11
Captured	0.4

A hospital however may make a report from a completely different base of reference viz. that of total admissions. These may be divided into battle casualties, injuries and disease. The mortality rate of battle casualties thus becomes based on the number of wounded admitted to hospital.

It is a seeming paradox of war surgery that the farther forward surgical treatment is initiated the higher will be the case mortality rate. It is obvious that the closer a hospital is moved to the front, the fewer will be the number of wounded who die before reaching it and the greater the number who die after admission. A surgical hospital adjacent to the clearing station not only receives wounded early but selectively receives only the most critically wounded. The mortality rate consequently may be 20

to 30 per cent of those admitted. Should such a hospital report a mortality rate of 5 per cent for example it would not be indicative of better surgical treatment but that the hospital is too far behind the front or that poor triage at the clearing station resulted in the admission of less seriously wounded.

The case mortality rate of wounded admitted to evacuation hospitals is 1.5 to 17 per cent. The mortality rate in a general hospital at the Base is lower (a fraction of 1 per cent) and will vary with the policy that determines the length of time patients are held before transfer to the Zone of the Interior. If this evacuation is rapid the hospitals of the Interior will absorb the delayed deaths from complications and reconstructive operative procedures.

The mortality rate for wounded admitted to a hospital will fluctuate with the type of combat in which the army is engaged. Any tactical situation that disrupts the normal function of the divisional medical service will dilute the stream of wounded that reach the hospital with large numbers of trivially wounded. In the month of April in a certain campaign with a static front the wounded admitted to hospitals numbered 1775 of whom 89 died (4.6 per cent). In May during a rapid offensive movement 10220 wounded were admitted to the same hospitals and only 174 (1.7 per cent) died. This was in spite of overcrowding, longer time lag and reinforcement of the hospitals with less experienced surgeons. An analogous tactical situation is presented in the establishment of a beachhead by overwater assault of a task force. Seriously wounded are likely to die on the beach and trivially wounded dilute the stream of those evacuated.

Lack of precision in the definition of the nature of the wound is very misleading. Thus the term abdominal wound may include any injury from a minor abrasion of the abdominal wall to one with extensive destruction of abdominal viscera. Systems of classification rarely provide for the tabulation of multiple wounds frequently listing only the one that is considered most important. It is often impossible however to indicate with certainty that a patient died of peritonitis when at the same time he had

a serious craniocerebral wound and perhaps a compound fracture of the femur in addition.

It is of utmost importance therefore that students of military surgery be cautious in the interpretation of statistics that are said to prove the efficiency of this or that type of treatment or the prowess of any individual surgeon or hospital. At times the mortality rate enables one to make a shrewd guess at the echelon in which the surgical work was carried on—nothing more.

### THE PHYSICAL NATURE OF TRAUMA

**Effects of High Velocity Missiles.**—The anti personnel effectiveness of an explosive projectile is determined by the number, size and the velocity of the fragments of the casing that are set in motion by its burst. The velocity of any single fragment decays during flight as a function of initial velocity, mass and distance of flight. The penetrating power of a flying missile depends not only on mass and velocity but also on the shape which in irregular fragments again varies with the orientation at the time of striking the surface of the target. The wounding power of a missile is more closely a function of its velocity than of its size or shape.

The irregular shape of a high explosive missile and its spinning or rotary movement like the wobbly phases of the flight of a conical bullet may determine the damage inflicted on the tissues immediately adjacent to its pathway. The wider and more extensive destruction of tissues that characterizes a wound inflicted by a high velocity fragment or bullet is attributable to the energy imparted to the tissues with an effect like an internal explosion. As in an explosion the rate at which the energy is delivered or the power that is expended is more important than the total energy absorbed so the destructiveness of a missile is a function of the cube of its velocity.

Particles in the track of a missile are thrown laterally or angularly by imparted energy that passes from particle to particle. The motion of tissue particles varies with the density of the tissue of which they are component parts. Thus a bone may be shattered and the dense fragments may continue as secondary missiles under their

own velocity through less dense muscle. In composite tissues made up of muscle and fascial planes a tearing disruptive action is exerted by the irregular stresses that are developed. In addition a stretching deformity is experienced by adjacent structures as they are distorted by the momentary creation of a cavity that marks the center of the explosive effect. The subatmospheric pressure within this cavity draws in some air a few bubbles of which may remain in the wound.

A missile that penetrates clothing and skin does not simply carry particles of foreign matter into the tissues along its track. As a rod carries a cleaning patch into a rifle barrel or as the 20th Century Limited trails flying papers and dust. By transmitted energy these foreign particles are dispersed widely through the tissues to a considerable distance from the missile tract.

**Blast**—Characteristic injuries are produced by the waves that are set in motion by detonation of an explosive charge either in air or under water. The effect of the blast wave itself must be differentiated from the concomitant effect of the flash (heat) and gas of the explosion from the injuries sustained by being thrown by the blast and from the independent effects of primary or secondary flying missiles falling masonry, broken gas mains and drowning.

The component of the atmospheric wave that produces injury is the shell of compressed gas that travels in all directions from the center of the explosion with a velocity of 2500 to 3500 feet per second. The velocity decays rapidly and probably is proportionate to the square of the distance from the explosion. The general physical effect of this wave is exerted by body impact and is that of a sudden blow on the chest or abdomen. Lung damage is the prime characteristic of the injury. In addition rupture of the ear drum and occasionally subserosal intestinal hemorrhage or actual rupture of the bowel results. The effects on the central nervous system have been carefully studied because of the confusion with "shell shock" of World War I. The occurrence of blast concussion of the central nervous system that is similar to traumatic concussion has been questioned.

In water with the detonation of a depth

charge a single high pressure wave is set in motion that travels at a velocity of 3000 feet per second. Its effect on an immersed body appears to be caused by the transmission of the pulse of the pressure wave without displacement of tissues. Only air containing organs (lungs and intestine) are affected and the lesions are similar to those produced by atmospheric blast. The predominant injury in cases of survival is rupture of the intestine.

**Acceleration and Deceleration**—Violent displacement by the impartment of motion to a static body or sudden stoppage of a rapidly moving body produces trauma that differs from the direct concussion of a blow. This has been studied particularly with regard to its effects on the central nervous system.

**The Pattern of Trauma**—When a group of individuals are simultaneously subjected to trauma the resulting injuries conform to a general pattern. This has long been recognized in civilian injuries and such entities as miner's elbow and bumper fracture are surgical classics. In warfare the military surgeon must be alert to recognize new patterns so that protective measures may be instituted. Among the patterns peculiar to war may be mentioned trench foot, land mine foot, high altitude frostbite, flash burns, "march fracture," "parry fracture" and desert sore. The name accorded to a pattern type injury may be misleading without shell shock. Careful search for a pattern by analysis of injuries is important when individuals are exposed to specialized situations as are airplane crews, tank crews, motorcyclists, turret gunners and parachute troops. Safeguards may be introduced by modifying the structure of the vehicle or airplane or adding protective armor.

**Causative Agents of the Wounds and Injuries of Warfare**—War releases the anemic violence in all possible forms and patterns. Injuries are commonly multiple and in the same individual often result from more than one type of trauma, e.g., burns and missiles, bomb fragments and falling masonry. The relative frequency of different types of flying missiles varies with the tactical nature of the operation—offensive or defensive land air sea or combined assaults, the strength of the position being

attacked or defended the arm or service of the participant and many other considerations. Thus service troops in the rear and in cities sustain wounds from aerial bomb fragments invasion of enemy held territory or crossing of river valleys increases the wounds from booby traps and land mines a strong opposing force of fighter planes adds explosive cannon shells to flak splinters jungle patrols encounter the small caliber rifle bullets of snipers and so on.

Causative agents of war wounds and injuries attributable directly or indirectly to enemy action are listed below. In addition there is a constant and high incidence of accidental injuries that is the inevitable result of having thousands of men exposed day and night to the hazards of assembling operating transporting and repairing heavy machinery explosives and petrol of modern warfare.

- 1 High explosive fragments artillery shells mortar shells airplane cannon anti aircraft flak and rockets and hand and rifle grenades
- 2 Land mines and booby traps high explosive fragments combined with secondary missiles of gravel and earth true shrapnel i.e. round metal balls in certain anti personnel mines
- 3 Bullets machine gun rifle small arms machine pistol etc
- 4 Aerial bombs anti personnel demolition and incendiary types
- 5 Bayonets rare and often accidental
- 6 Flame and flash explosives cordite petrol and phosphorus
- 7 Secondary missiles armor plate plastics concrete masonry etc
- 8 Violent displacement airplane and glider crashes parachute landings being thrown by a blast and tank and other vehicle crashes
- 9 Exposure to elements frostbite trench and immersion foot heat stroke dehydration high altitude frostbite and immersion
- 10 Agents of chemical warfare vesicant irritant, poisonous corrosive and incendiary
- 11 Agents of biological warfare strategic use of endemic disease spread of epidemic disease

**Regional Distribution of Wounds from Flying Missiles**—Projections of the surface of the body as a silhouette target have been found to yield the following measurements for regional subdivisions

	Per cent
Head and neck	10
Upper extremities	20
Lower extremities	39
Trunk	27

As a vast majority of wounds are from a random distribution of high explosive fragments or machine gun fire it would be expected that the regional distribution of wounds on the body would also be random and would coincide with the foregoing percentages. Several variables come into play two being most important. First statistics on wounds are derived from wounded who survive to reach a hospital and differential immediate lethality may be an important item. Second protective measures such as the steel helmet the use of trenches and armored vehicles interfere with a random hit of the vulnerable target. That the actual statistics do conform in general to the above pattern is shown by the following samples.

(a) 178 014 wounds in the A.E.F. World War I

	Per cent
Head and neck	11
Upper extremity	36
Lower extremity	45
Trunk	8

(b) A large number of casualties in World War II classified as to the most extensive wound

	Per cent
Head	10
Upper extremity	23
Lower extremity	40
Trunk	25

#### GENERAL EFFECTS OF TRAUMA

**Hemorrhage**—Arterial spasm initiated by the violence of the trauma is a potent factor in preventing death by exsanguination. At times the spasm may persist and in itself produce ischemic gangrene or possibly may be a factor in the establishment of infection. Hemorrhage is controlled by a pressure bandage direct clamp and ligature or when other measures fail by a tourniquet. When a limb is hopelessly mangled

so that amputation is inevitable the tourniquet is applied just below the level of proposed amputation and left in place until the operation is completed. The systemic effects of blood loss merge with other factors that reduce the blood volume and result in shock.

**Shock**—Shock is the disturbance of homeostasis produced by a reduction in the circulating blood volume. The pattern of the reaction as observed clinically is variable and there is no single measurement that records its progress or severity with exactitude. A wounded soldier may walk into a receiving tent showing nothing but slight pallor and yet may be in early shock. From this minimal disturbance the condition extends to that of the widely quoted classic picture of advanced shock sketched by John Collins Warren in 1894.

Reduction in the circulating blood volume is initiated by loss of blood or fluid at the site of injury. Injury includes trauma either mechanical or thermal and infection that appears as a complication. There is no evidence to confirm the hypothesis that increased capillary permeability remote from the site of injury results in the loss of additional plasma until the agonal stage is reached.

Peripheral vasoconstriction goes a long way toward determining the clinical appearance of a patient in shock. The intensity of this reaction varies not only with the volume blood flow but also with the coexistence of certain sympathico-adrenal stimuli such as cold, pain, fear and asphyxia. The intensity of the vasoconstriction also varies with age, sex and general condition. Young adult males unweakened by disease react vigorously to loss of blood volume by peripheral vasoconstriction and so provide the dramatic picture of the 'wound shock' of warfare.

Certain bodily changes associated with shock take place only after the circulation becomes inadequate. Each tissue has a limiting point at which it dies from asphyxia. Pathologic changes in tissues and organs generally reflect the length of time during which the circulation was inadequate. Functional impairment or complete and irreversible suppression of function may occur in certain organs, e.g., the kidneys and

delayed death of the entire organism may result despite the fact that other organs have been resuscitated. Shock in itself is not irreversible until agonal changes ensue.

In the treatment of shock, whole blood is the agent of choice. There is no adequate substitute. Partitions of blood—plasma, serum or albumin—containing the osmotically active plasma proteins are of value as first aid measure in tactical situations where it is impossible to supply whole blood. They are also of use in injuries characterized by the loss of plasma rather than of whole blood such as burns, massive infection, peritonitis and crush injuries. In these types of trauma a high hematocrit reading is typically found.

Morphine is administered only to relieve pain and thus indirectly treat shock. The dosage should not be large. If an effect is not obtained absorption from the subcutaneous tissues is probably delayed and repeated doses will lead to the sudden absorption of a toxic amount when the circulation is restored. Immediate splinting of the injured part not only relieves pain but minimizes local fluid loss and prevents further tissue damage. Oxygen is administered if the asphyxia resulting from reduced blood flow is being augmented by faulty oxygenation of the blood. The respiratory passages are cleared and any condition crippling the normal action of the heart and lungs is eliminated. Dehydration is corrected by fluid therapy. Body heat is conserved but heroic measures to warm up a shocked patient are dangerous. Vasoconstrictor drugs and stimulants are harmful. The value of extracts of various glands of internal secretion has not been confirmed.

Army hospitals for battle casualties set up a special receiving section known as the 'Shock Ward' or 'Preoperative Ward'. Here wounded men in shock are treated under close supervision until their condition is such that they will withstand necessary surgical treatment. Whole blood is available through a blood bank system that extends back to a blood collecting center in the adjacent Base. Plasma in dry form is provided from the large civilian donor reservoir in the Zone of the Interior.

As a wounded man is resuscitated from shock, an opinion must be formulated as to

when his condition will withstand operation. The goal of shock therapy in the wounded is not only to maintain life but to get the patient into equilibrium so that necessary surgical treatment may be given. It is for this reason that whole blood transfusion is so essential. Movement of the patient, anesthesia and operation with its further blood loss place severe demands on the circulatory system and on vital organs that have been partially asphyxiated during the period of shock.

**Fat Embolism**—Two predominant clinical manifestations of fat embolism follow trauma—pulmonary and cerebral. They appear to occur most frequently following fractures. The pathology and symptomatology are based on minute multiple emboli of droplets of fat. The pulmonary type is likely to be confused with the effects of blast injury on the lungs but usually shows a longer time-lag between injury and onset of symptoms. The cerebral type is confused with the effects of concussion particularly if there is a head wound. It may closely resemble the cortical decerebration of asphyxia.

## THE WOUND AND ITS MANAGEMENT

**The Wound and Wound Infection**—Wounds produced by flying missiles present infinite variations in size, severity, parts of the body that are injured and the effects on the body as a whole. One basic characteristic, however, is common to all wounds—local destruction of tissue with a heavy seeding of microorganisms. For this reason the surgical problem of the wound is inextricably bound with that of wound infection. As all wounds are contaminated, it becomes a matter of academic definition as to when contamination is projected into infection. Considering solely the time factor, this has been arbitrarily set as after the lapse of six hours. As so defined, the vast majority of wounds sustained in land warfare are already infected at the time surgical treatment is initiated.

To understand the nature of wound infection, it is necessary to distinguish between bacterial growth limited to the tissues that were devitalized by the injury and invasive infection that starts in the wound and extends to living tissues. The former may be

termed *surface infection with injury necrosis*; the latter *invasive infection*.

In the natural process of sequestration of dead from living tissues, bacterial activity plays an active role in proteolysis. A purulent exudate is called forth which blends with liquefying necrotic tissue and literally teems with bacteria. Liquefaction and sequestration of dead muscle may be rapid and the slough pours from the wound as thick and oftentimes malodorous pus. When fascia, tendon or bone have been devitalized either by the direct impact of the missile or by destruction of the blood supply, these tissues are cast off as sloughs or sequestrums. The process is delayed because of their firm attachments to living structures.

Waiting for the sequestration of dead tissues to take place by natural processes is what is called allowing the wound to clean up. Proteolytic bacteria appear to aid this process. Certain oxidizing chemicals hasten the process of liquefaction of dead tissue. The hypochlorite solution of Dakin, with a pH adjusted so that injury to living cells is minimized, was developed in World War I and has this action. Unfortunately, attention became focused on the bactericidal action of Dakin's solution and it was considered that it was the infection that was being cleaned up.

The bacteria that flourish in dead tissue are predominantly anaerobic in their cultural characteristics and proteolytic in functional activity. A wide variety of clostridial forms find the wound a favorable habitat for growth. In a deep wound with a small aperture to the exterior, gas may be formed under such pressure that it dissects its way along tissue planes to a considerable distance from the wound. Or it may accumulate in a pocket to form a gas abscess. As certain organisms of the mixed flora produce soluble toxins, these may be absorbed and produce fever, malaise and other systemic effects, less clearly understood. This type of wound infection—surface infection with injury necrosis—appears in wounds in which surgical treatment is delayed or becomes manifest after incomplete surgical treatment that leaves a residuum of dead and devitalized tissue. Collections of blood or serum in the wound behave like dead



tissue when infected. Evidence of inflammation in surrounding tissues is minimal or absent or is attributable to the injury rather than to the infection.

*Invasive infection* starting in the wound is usually initiated by a mixture of these same organisms. Its extension is typically by direct continuity along fascial planes and is productive of necrosis of fascia and connective tissue. Edema of the skin and subcutaneous tissue with pain and tenderness marks the course of the underlying phlegmonous extension. Localizing abscesses at times containing gas and malodorous pus are formed. Invasive infection of wounds rarely takes the form of classic lymphangitis with regional infection of lymph nodes. Blood borne metastases are extremely rare. Persistent bacteremia when it occurs is usually indicative of septic thrombophlebitis and is uncommon.

The term *anaerobic cellulitis* has been proposed to include both the surface infection with injury necrosis and the invasive infection of fascial planes and connective tissue. It is not a satisfactory term from the standpoint of either the bacteriologist or the pathologist but it is useful clinically to establish a composite entity that stands in contrast to "gas gangrene" or clostridial myositis.

Certain clostridia that are commonly present in wounds may invade and necrotize living muscles with alarming speed and rapidly fatal result. The term "gas gangrene" is properly limited to this type of invasive infection but because it is a loose and incorrect term it has been replaced by the more specific designation *clostridial myositis*. Certain species particularly *Cl. perfringens* (B. welchii), *Cl. oedematis*, *Cl. ordellii* and *Cl. septicum* (*Vibrio septicum*) have been isolated most frequently in this type of infection. At times they appear to act singly but most frequently they act in association or combination with other organisms. Attempts to correlate the clinical course and local characteristics of the infection with a specific organism provide patterns that are to be considered valid only in the broadest sense. Clinically the "dry" or emphysematous type of gas gangrene appears associated with *Cl. perfringens* as the predominant organism in a majority of cases.

The "wet" or edematous type of infection has been linked with *Cl. oedematis* in many instances and also with *Cl. ordellii*. The difficulties of cultural isolation pathogenicity tests and species identification superimposed on the almost invariable presence of a mixed bacteriologic flora and the lack of immunologic methods for determining resistance or response of the individual subject to specific organisms or strains leave many gaps in the evidence. At present it is better to regard clostridial myositis as one of the broad patterns of wound infection rather than a monobacterial entity.

The onset and course of clostridial myositis may be and usually is rapid and fulminating. Pain is often the first symptom. Symptoms that are attributable to loss of blood volume into the area of progressing infection are grouped as shock and are characteristically those of a reduced volume flow. Symptoms that are attributable to a soluble toxin are less clearly defined but it may be significant that high fever delirium and rapid pulse appear to be improved by antitoxin administration.

**The Initial Wound Operation.**—The initial surgical treatment of a wound is commonly referred to as *debridement* according to American usage of the term. It consists of excision of all dead or devitalized tissue. Some confusion exists in the use of this term as French surgeons employ their word *debridement* to describe the opening of the wound by incision so that all recesses are exposed. The actual removal of the dead tissue is the second step of the complete operation and is known by the French as *éclueage* or *parage*. There is a subtle quantitative distinction between these latter two procedures. *éclueage* is a peeling of the inner surface of the wound. *parage* a more radical prying. The term *excision* as used by the French to indicate extirpation of the wound *en bloc* as one would extirpate a malignant tumor and as similarly employed by Bulea is avoided by Americans as a theoretical rather than a practical concept.

There is a certain amount of merit in a terminology that recognizes the two steps in the initial surgical treatment of a wound that the French preserve in the terms *debridement* and *parage*. It is a common mis-

take for the beginner to fail to make a free incision of the wound before he attempts extirpation of devitalized tissue. Failure to make a free incision is likely to be combined with excessive excision of skin to gain exposure. This is an error for little if any skin need be excised to prevent infection and excision of skin adds material difficulty to secondary suture.

Foreign bodies that lodge in or near the wound are removed at the time of the initial operation. Preoperative roentgen ray examination is for this reason an important step in surgical management. The significance of a foreign body particularly a fragment of the missile resides in the fact that it marks a pocket of the wound that con-

(not packed) with fine meshed gauze which if desired is impregnated with petrolatum. The wound is supported by a firm bandage or a light plaster of paris shell for immobilization.

The principles involved in the no-suture technic of wound management as contrasted with primary suture are debated at the start of every war. Even in the management of civilian injuries they provoke endless discussion. There appears little doubt that a great many war wounds would heal by primary union if they were closed by primary suture. However no surgeon can predict with certainty which wounds will become the site of life endangering invasive infection if closed. Particularly regarding large



Fig 41—Reparative surgery of soft part wound of axilla. A First dressing at base hospital four days following initial debridement and forward evacuation to hospital. B Closure of wound by secondary suture with a transposition of skin flap into axilla. C First dressing on patient eleven days after suture, sixteen days after wounding.\*

tains dead contaminated tissue. Later a foreign body acts as an infected sequestrum that cannot be extruded spontaneously by the body. Foreign bodies are by no means limited to fragments of the missile. Pieces of masonry parts of vehicles and bits of uniform are frequently found in wounds. Fragments of bone completely detached from their blood supply are foreign bodies. Also parts of the body may be displaced by the missile so that an avulsed thumb is found in a deep wound of the thigh or scalp with hair attached in a wound of the neck.

Careful hemostasis is achieved during and at the end of the operation. No sutures are placed in the wound. It is left loosely filled

and complicated wounds no surgeon can exert infallible judgment in the recognition of dead and devitalized tissue unless the wound were to be excised *en bloc* as is a malignant growth with undue sacrifice of normal tissues. Further the approximation of tissues by sutures creates areas of ischemia or actual necrosis. While such areas may be unimportant in a surgical incision made under the safeguards of asepsis they will act as focal points for invasive infection in a wound that is heavily contaminated. The necessity for early transportation of the patient in the postoperative period the interruption of continuity of professional

\* Churchill E. D. Ann Surg 120 J. B. Lippincott Co. Publisher

supervision and other considerations inherent in the management of wounded in the field combine with the aforementioned reasons to make the no suture technique an established principle of military surgery.

**Surgical Management of Wound Infection**—The initial surgical procedure of debridement is carried out in accord with the same principles even though proteolytic infection of the devitalized tissues has established itself clinically. If local invasive infection is present radical incisions are made to expose and remove tissues that are necrotic as a result of the initial trauma or that have been devitalized by the infection. Fascial plane abscesses are given free drainage. Respect for barriers to infection established by the defense mechanisms of the body has no place in dealing with the type of post traumatic sepsis under discussion.

Successful treatment of clostridial myositis depends on early diagnosis and prompt radical management. Surgical excision of involved muscles is the basic principle of effective therapy. This may take the form of amputation of an extremity if the limb will be left crippled by the necessary operative treatment or if the vascular integrity has been jeopardized by the initial trauma. Maintenance of blood volume by transfusions is essential. The prophylactic value of polyvalent antitoxin appears negligible but antitoxin is used in the therapy of the established infection.

**Reparative Wound Surgery**—Leaving a wound open at the end of the initial operation minimizes the likelihood of early infection, particularly of the anaerobic type. It also affords free drainage to surface infection of necrotic tissue if the debridement has been incomplete. These are the advantages of the method. The disadvantages lie in the problem of healing that is imposed. The open wound is exposed to the hazards and complications of air borne infection and cross infection despite the most rigid dressing techniques. All of the disadvantages of healing, by granulation and slow epithelialization are incurred. Disturbance of the surface of the wound by change of dressings promotes infection and febrile reaction and leads to the progressive cachexia of chronic sepsis.

In civil experience this state of affairs

was commonly encountered in the management of osteomyelitis because of the slow sequestration of bone and the large soft tissue defects that complicate the surgical treatment of this disease. To solve the problem Orr introduced the closed plaster method of management which provides immobilization and reduces the complications that arise from frequent dressings. During the Spanish Civil War Trueta adapted the closed plaster method to the management of war wounds reviving a principle that had been utilized by Pirogoff in the Crimean War. Trueta insisted upon meticulous debridement enclosing the wound in plaster of paris and leaving it alone for a number of weeks. If proteolytic infection of residual dead tissue takes place the exudate absorbed by the plaster the complete immobilization appears to reduce lymphatic absorption to a minimum. As a consequence the general condition of the patient does not deteriorate. Detachment of dead tissue by bacterial and natural proteolytic action finally is completed and when the cast is removed a clean granulating surface is found.

There seems little doubt that this method is of value in war surgery when enormous numbers of wounded must be cared for by relatively few medical officers. It has been used extensively in Russia and also in England. On the other hand when applied to compound fractures a high price is paid in skeletal deformity as many fractures cannot be held in satisfactory alignment by plaster alone. Incorporation of pins in plaster as proposed by Trueta has been found unsatisfactory when the patient is subject to transportation. When the method is applied to wounds of the soft parts it entails prolonged hospitalization and delay in return of the soldier to duty. The slow healing exaggerates scar formation and late cicatricial contracture.

During 1913 in the North African Theater attention was directed toward the old problem of wound closure by secondary culture. In 1914 as the initial surgical treatment of wounds reached a high standard of perfection in the forward area the program of wound closure in the base was extended. When penicillin became available wounds complicating fractures were closed or re-

duced to a size compatible with the completion of natural healing at the time bony union had occurred.

Secondary suture of wounds thus emerged, from a procedure about which there was considerable controversy, to the status of a universally accepted routine. Wound management has become a two stage operation—initial surgical treatment in the forward area at the earliest moment after injury, reparative surgical treatment at the base between the fourth and the tenth day. The original dressing applied after débridement

tion. A notable contrast exists with the Carrel-Dakin ritual of World War I, in which secondary closure was based on quantitative and qualitative bacteriologic examinations of the wound secretions. These laborious and meaningless tests have been totally by-passed in World War II.

How greatly the use of sulfonamides and penicillin has contributed to the success of this development is impossible to say at the present time. The employment of either one or the other or a combination of the two agents has been an integral part of the ini-



Fig 42—Tangential wound of calf producing skin and soft part defect measuring four by five inches. Secondary débridement at base hospital on twelfth day following initial débridement. Immediate split thickness skin graft. First dressing shown five days later (seventeen days after wounding). No chemotherapy for reparative surgery.\*

in an evacuation hospital is removed in the operating room of a general hospital several hundred miles to the rear and the operation completed. If the débridement has not been complete, further excision of dead tissue is carried out and closure delayed a few days.

A striking aspect of this development in military surgery is that gross pathologic changes have replaced bacteriologic analysis in forming a judgment relative to the performance of secondary suture. This further confirms the general principle that dead tissue is the key to early wound infec-

tial wound management. Suture of soft part wounds has been successful without either agent at the time of reparative surgical treatment. In complicated wounds, a course of treatment with penicillin has appeared advisable.

A pressure splint undisturbed for eight to ten days and removal of skin sutures as late as the tenth to twelfth day are important to the technics of secondary suture. The procedure should be undertaken only

\* Churchill Ann Surg 120 J B Lippincott Co., Publisher

in fixed hospitals where the patient can remain at rest for fifteen days or for a longer period.

The general principle that the time lag between injury and initial surgical treatment is a determinant golden period in wound infections may now be supplemented by recognition of a second critical golden period—that between the initial and the reparative surgical treatment. Fortunately the time-lag of this second period has been shortened by air transport of the wounded from the forward area to the rear.

**Sulfonamides and Penicillin**—Two important adjuncts to the surgical management of wounds have been available in World War II—the group of chemotherapeutic agents known as the sulfonamides and the antibiotic substance penicillin. Both are bacteriostatic and to a lesser degree bactericidal. Their effects are known to be highly selective for certain groups, genera, species or strains of micro-organisms. The sulfonamides are inactivated by the products of tissue necrosis in which para-aminobenzoic acid may or may not be the active inhibitor. Penicillin is rapidly decomposed when applied topically and quickly excreted when administered parenterally. The ability of either agent to permit dead tissue by diffusion is limited. Their ability to diffuse into body cavities varies.

Both the sulfonamides and penicillin have been used in topical application and systemic medication. They have been used singly and in combination for polybacterial and monobacterial infections in which the bacterial flora has been known, partially known or totally unknown. They have been used both for prevention of infection and for treatment of established infection.

Any attempt to evaluate a subject of such baffling complexity would obviously be premature. It seems likely that a controlled evaluation may never be possible as some or all of these agents become replaced by more potent preparations. For descriptions of the modes and fashions of the usage of these agents reference should be made to the current literature. (See the chapter on Chemotherapy.)

The statement that chemotherapy is not a substitute for surgical treatment in the management of wounds has been made so

frequently that its true significance has been lost in repetition. A restatement of certain basic facts is in order.

1 The key to infection in war wounds appears to be tissue devitalized by the missile and contaminated by a mixed bacterial flora.

2 Blood clots and hematomas when contaminated are comparable to masses of necrotic tissue.

3 Bacterial invasion of living tissues when it occurs is likely to take the form of a necrotizing infection with further tissue destruction oftentimes massive as in clostridial myositis.

4 Dead fasci, tendons and bone become detached from living tissue only by a slow process of sequestration. Spontaneous extrusion of sequestered tissues or of foreign bodies of external origin may in fact be impossible.

5 Precise identification of the mixed bacteriologic flora of wounds with significant testing of individual species or strains for human pathogenicity, toxin production and sensitivity to chemotherapeutic or antibiotic agents is a formidable even impossible task. Laboratory techniques are often controversial or inadequate. For this reason the use of sulfonamide and penicillin in the management of wounds must remain empirical at least at present being based on a knowledge of the properties of these agents supported by clinical experience.

6 The use of sulfonamides and penicillin in military surgery is properly directed toward the extension of the scope of surgery and the achievement of results heretofore considered impossible. They should not be utilized to permit delay in the surgical treatment of wounds or to minimize the completeness of the excision of dead tissue or the surgical drainage of pus.

**Anesthesia**—In any consideration of anesthesia for military purposes it is necessary to distinguish at once between that carried out in the forward or combat zone on the freshly wounded in the field or evacuation hospital and anesthesia employed in the rear at the station or general hospital and taken usually many days following the initial trauma. In the latter type of anesthesia there is no way from that in civilian practice.

What constitutes good anesthesia for the man who has just been wounded was at one time a matter for considerable controversy. With increasing experience surprisingly general agreement has been achieved. The common views can now be summarized as follows:

1 When long operations (beyond forty minutes) are considered or whenever a patient is in poor general condition or when ever his wounds are such that shock is present or to be anticipated ether anesthesia has proved to be best by a wide margin.

2 Intravenous anesthesia (pentothal) is of great usefulness. It provides for 60 per cent of the anesthesia in the forward zone but for a reasonable degree of safety its use must be restricted to brief (under forty minutes) procedures on able-bodied men in good condition. Procedures where muscular relaxation is not needed. Its use is particularly to be avoided for patients who have suffered considerable blood loss even though their wounds are otherwise trivial. Shock or impending shock contraindicates pentothal. Gas gangrene contraindicates the use of pentothal. Experience has shown that its use is unwise in burned patients in intracranial explorations for operations that involve the airway or in any circumstance in which oxygenation is likely to be impaired.

3 Local anesthesia is occasionally useful for this group of patients but generally speaking the state of mind of the man who has just been wounded is such that general anesthesia is usually the best choice. During periods of heavy action complicated regional blocks are of little use. They are time consuming and require technical experience that is not widely available. The usual multiplicity of wounds in a given individual further minimizes the value of this technique. Two blocks however are widely employed in the forward zone: intercostal nerve block to relieve pain and to effect splinting in injuries to the chest wall and sympathetic blocks to improve blood flow to extremities when interference with the blood supply has occurred.

4 Spinal rectal and chloroform anesthesia have no place in the treatment of the freshly wounded man.

## SPECIALIZED PROBLEMS OF REGIONAL SURGERY

**Wounds of the Extremities—Fractures**  
—Wounds of the extremities account for approximately 60 per cent of the admissions to the hospital. Between 20 and 30 per cent of extremity wounds are complicated by a compound fracture. In hits from high velocity missiles the bone may be badly shattered and comminuted often with extensive defects of substance. The detailed management of fractures is in accord with principles established in civilian practice with necessary adaptations of the timing of procedures to the need for evacuation of the patient.

First aid splinting in the field brings the patient to a hospital for initial surgical treatment. Definitive reduction and fixation of the fracture is not attempted at the forward hospital but attention is directed toward the prevention of infection by surgical treatment of soft part wounds. The extremity is then immobilized by a method that has been found suitable for transportation to the base. At a fixed hospital in the base definitive reduction and fixation is accomplished and the patient is held until bony union takes place. Thus the management of a compound fracture is divided into phases: first aid splinting in the field; debridement and transportation splinting in the forward area; correction of the deformity with achievement of wound healing and bony union at the base; late corrective surgical treatment (bone grafting, osteotomy, etc.) in the Zone of the Interior.

**Vascular Injuries**—It has been estimated that in 1 in every 600 cases of wounds of the extremities an injury to a major vascular trunk independent of other damage jeopardizes the integrity of the limb. Many variables aside from the usually considered anatomical site of the vascular interruption may play a part in determining whether ischemic gangrene results or the level at which amputation is necessary. Some of the variables of the initial injury are as follows: severance or thrombosis of the accompanying vein; concussion or division of nerve trunks; the extent and character of the soft part wound in association with the vascular injury; the presence or absence of skeletal injury or other wounds in the same extremity; the severity and duration of the reduc-

tion in cardiac output during the phase of shock, environmental temperature and the pre existing peripheral vascular state of the individual patient. An all important variable in determining the outcome is the extent and nature of any complicating infection that may develop in particular clostridial myositis.

Therapy includes a wide range of procedures, no single one of which is curative. The selection of therapeutic measures and the sequence in which they are applied vary greatly from case to case. Procedures that have been recommended and that experience has shown to be helpful are: double ligation with complete division of the artery, ligation of the companion vein, novocain block of the sympathetic system, sympathetic ganglionectomy, maintenance of a cool environmental temperature, establishment of a normal cardiac output and oxygen carrying capacity of the blood, a dependent position of the extremity and administration of certain vasodilator drugs. Reconstruction of the artery only rarely is feasible but should be carried out with the vitallium tube technique when practicable.

Principles that govern the management of arterial aneurysms, arteriovenous fistulas and pulsating hematomas, all of which are encountered with considerable frequency in war surgery, are identical with those formulated by civilian experience.

**Amputations**—Amputation of an extremity is a procedure intimately linked with the evolution of surgery and the history of the battlefield. There are three major reasons for amputation—a hopelessly mangled limb, infection and vascular insufficiency. Many amputations are merely completions of traumatic amputations. In World War II the immediate effects of trauma have been found to necessitate amputation in 64 per cent, infection in 13 per cent, vascular insufficiency in 20 per cent and a combination of vascular insufficiency and infection in 3 per cent of a series of surviving patients. Infection thus played a role in the decision to amputate in 16 per cent.

The technical aspects of amputation have been standardized throughout the Army and closely coordinated with the program of rehabilitation and the fitting of prosthetic appliances.

**Peripheral Nerves**—Peripheral nerve palsy may result from the concussive effects of a missile or anatomical severance of a nerve. In the former function usually returns within a few weeks. The management of direct nerve injury remains one of the least satisfactory procedures in the field of military surgery.

Suture of a divided nerve at the time of initial surgical treatment of a wound has been held ill advised although from the standpoint of nerve regeneration this would appear to be the ideal time. It is generally considered that nerve repair requires aseptic healing and perfect hemostasis. Neither of these conditions can be achieved in a significant number of complicated wounds. Degenerative changes in the nerve trunk secondary to high velocity penetration may not be immediately apparent. The gross changes are necessary to guide the surgeon in the resection of the traumatized ends of the nerve as a preliminary step to suture.

The great majority of patients with nerve injuries in World War II will be subjected to delayed surgical repair—after the healing of the wound. The results will admittedly leave much to be desired.

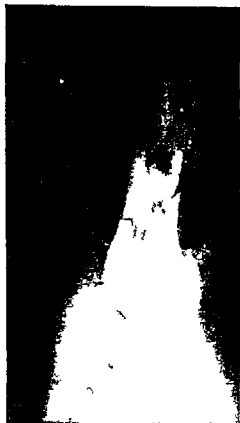
**Joints**—Suppuration with its disastrous consequences is likely to develop in the presence of bone or cartilage injury. Early wide arthrotomy with precise drainage of soft parts, bone and cartilage is recommended. The joint cavity is irrigated with normal saline solution and penicillin is instilled. The objective is a closed joint cavity obtained by suture of the synovial membrane or repair of a capsular defect by fascial or soft part flap. The skin is left unsutured and the joints above and below are immobilized; for example, an injured knee joint is splinted by a hip spica.

**Cranio cerebral Wounds**—About 6 per cent of the men wounded in action and admitted to a hospital have a head wound as the major injury. There is a high immediate mortality on the battlefield from this cause; it has been estimated that 40 per cent of all men killed in action have wounds of the head and 25 per cent have only head wounds.

The pressure effects that constitute such an important problem in the management of closed head injuries are far less frequent in



A



B



C



D





E

Fig. 43.—Reparative surgery of wound compound, fractures of both bones of the forearm and fracture-dislocation of the humerus. A, First dressing at base hospital on fifth day. Secondary anemia corrected by 1600 cc. of whole blood. Penicillin therapy. B, Screw fixation of comminuted head of the humerus following open reduction of dislocation. C, Reduction of fracture of both bones of the forearm with wiring at fracture site of the radius. Application of skeletal traction. D, Wound closure. E, Postoperative skeletal traction.\*

the penetrating wounds of the head that are encountered in war.

Cranio-cerebral wounds form a notable exception to the general principle that wounds should be left open after the initial operation. For this reason, the primary operation must be the definitive one, with complete removal of devitalized tissue, indriven fragments of bone and the missile itself, if

large and accessible through the wound. Débridement is followed by closure of the dura with a fascial graft, if necessary, and suture of the scalp. The operation requires specialized skill and equipment and, as a rule, is undertaken in an evacuation hospital.

The reason that craniocerebral wounds are closed primarily is found in the disastrous sequelae of deep infection within the brain. Edema and swelling cause extrusion of brain substance through an open defect, with the formation of a self-strangling fungus. Spreading cerebritis and meningitis may find origin in the extruded portion. *Even in late cases, with established infection in the devitalized brain substance, large defects in supporting structures must be avoided.*

**Maxillofacial Wounds.**—Mutilating wounds of the face and jaws are the most dreaded of war injuries. Early expert management can greatly reduce the ultimate disfigurement and functional disturbance. The incidence is not great, approximately 2.5 per cent of the wounded admitted to the hospital having maxillofacial injuries, many of these of slight consequence.

First-aid measures maintain a clear airway to prevent suffocation. Tracheotomy may be necessary. Surgical management is first directed toward reduction and fixation of osseous deformities, with particular attention to re-establishment of normal dental occlusion.

The soft part injuries are a specialized problem. The tissues of the face tend to retract widely because of their heavy intrinsic musculature. Compounding of the buccal cavity makes some degree of infection inevitable, although life-endangering infection is unusual because of the abundant blood supply. This combination of retraction and fibrosis from infection appears more important in the production of disfigurement than tissue loss caused by the missile. Suture of these wounds is therefore undertaken at the time of the initial surgical treatment. Moist pressure dressings, drainage of dependent areas in anticipation of sepsis and chemotherapy are adjuncts to management.

**Wounds of the Chest.**—In approximately 10 per cent of the wounded admitted to a hospital the major injury is of the chest.

\* Clarendon Ann Surg 1932 J B Lippincott Co., Publisher

As with head injuries there is a high immediate battlefield mortality

In the management of thoracic wounds two distinct phases may be encountered—physiologic disturbance of the function of the cardiorespiratory system and infection. Physiologic disturbance must be corrected immediately in the most forward surgical installation. The hazards of infection are less urgent and may be controlled in an echelon farther to the rear.

One of the most urgent complications is *open pneumothorax*—the so-called *sucking wound*. This must be closed immediately by a compress of gauze held in place by adhesive plaster. Closure by suture is not advisable, as tight closure is likely to be followed by pressure pneumothorax and surgical emphysema. After the patient reaches a surgical hospital the wound is debrided, hemostasis is effected and the deeper structures of the chest wall are approximated by suture so as to close the pleural cavity.

Pressure pneumothorax is controlled by insertion of a catheter with a flutter or water seal valve. Needle aspiration of air and blood from the pleural space, aspiration of blood and mucus from the tracheobronchial tree by catheter or bronchoscope, novocain injection of intercostal nerves, oxygen therapy and transfusion are important measures in the early management of thoracic injuries.

Indications for early thoracotomy either by extension of the wound or by separate incision at the site of election include continuing intrapleural hemorrhage not controlled by hemostasis in the chest wall, debridement, anatomic or clinical evidence that the missile may have penetrated the diaphragm, traverse through or lodgment of a missile in the mediastinum with possible visceral damage, large intrapleural foreign bodies or debris that is readily accessible by extension of the wound and wounds of the large bronchi.

Late complications are controlled as indications for intervention develop. Large intrapulmonary foreign bodies, particularly the irregular shaped high explosive fragments, are removed surgically. Residual hemothorax is managed by repeated aspiration. Large collection of clotted blood that can no longer be aspirated by needle and

show little evidence of absorption are evacuated by thoracotomy with decortication of the lung.

Post traumatic emphysema may require surgical drainage or preferably a more radical thoracotomy. Complete removal of residual clotted blood with decortication of the lung even in the presence of infection promotes rapid healing and full restoration of pulmonary function. Penicillin is utilized both systemically and locally in the pleural space. Every effort is made to prevent or cut short the complications of thoracic wound that lead to chronic disability.

**Wounds of the Abdomen**—In 3 to 5 per cent of those wounded in action who survive to be admitted to a hospital the wound is classified as abdominal. Of these 85 per cent or less have penetration of the peritoneal cavity with injury to one or more hollow or solid viscera. Concomitant injuries from the same or other missiles are present in three fourths of the cases and contribute materially to the mortality rate. One fourth of the cases are complicated by compound fractures or traumatic amputations.

The mortality rate for the group with visceral penetration is 35 per cent if deaths from late complications are included. Of those who die 42 per cent succumb to immediate sequelae of the wounds—hemorrhage and shock—or to irreparable destruction of vital organs. In 27 per cent death is due to pulmonary complications, peritonitis and associated injuries.

The critical decision is when to operate. If the state of shock does not respond rapidly to infusion of blood and plasma it is a fair assumption that there is continuing hemorrhage or established peritonitis and operation must be undertaken despite the poor condition of the patient. Transfusions are continued during and after the operation.

**Small Bowel Perforation**—Perforation of the small intestine is found alone in 20 per cent of cases and associated with other visceral wounds in an additional 20 per cent. Repair is made by suture or resection and anastomosis as the damage indicates. Exteriorization of the small bowel or double-barrelled enterostomy may appear to solve an immediate problem but leads to grave

complications and is to be avoided at all cost

**Large Bowel Perforation**—Perforation of the large intestine is found as the only injury in 10 per cent of cases and associated with other visceral injury in an additional 26 per cent. The distribution of injuries from cecum to rectum appears to be random. Patients with injury to the colon comprise the group with the highest mortality rate—approximately 50 per cent. When the colon alone is injured the death rate is not greatly different from that in cases of small bowel perforation.

In the surgical management of wounds of the large bowel the perforated segment is mobilized to permit exteriorization through a laterally placed separate abdominal incision. In the rectosigmoid area where mobilization is impossible the perforation is inverted by suture and proximal colostomy is performed. When circumstances permit exteriorization of a segment of large bowel is made with a view to later closure by crushing with a spur clamp.

Wounds of the rectum are characterized by inaccessibility, difficulty of diagnosis, a frequency of damage to other structures and the hazard of ascending retroperitoneal cellulitis. Every wound of the rectum demands a laparotomy and with any perforation of the rectum above the sphincter colostomy is mandatory. The perforation of the rectum need not be sutured but wide posterior drainage is established.

**Spleen**—Injury to the spleen is found in 7 per cent of cases and as the only injury in 2.3 per cent. When the spleen alone is involved the mortality rate is 13 per cent. Splenectomy is the operation of choice.

**Liver**—Wounds of the liver are found in 30 per cent of cases. The mortality rate when the liver is the only viscus involved is 15 per cent. Hemorrhage may have ceased from small wounds of the liver if so they are not disturbed. High velocity penetrations may produce a shattering fracture of the liver that requires packing with gauze to control hemorrhage and drainage at dependent sites to provide for evacuation of escaping bile.

**Kidney**—Conservatism is the rule in dealing with the 10 per cent of penetrating abdominal wounds that involve the kidneys.

Nephrectomy is done for fragmentation of the organ and continuing hemorrhage.

**Urinary Bladder**—Perforation of the bladder occurs in 4.7 per cent of cases and is usually associated with wounds of other viscera. Repair is accompanied by suprapubic cystostomy in all cases.

**Retroperitoneal Hemorrhage**—Hemorrhage into the mesentery or in the retroperitoneal space presents signs and symptoms that may be indistinguishable from those of perforation of a viscus. Unless there is continuing hemorrhage no intervention is indicated after perforation of the bowel is excluded at laparotomy.

**Trench Foot and Immersion Foot**—Injury to the feet by cold and moisture for years has been an important cause of ineffectiveness in armies during winter campaigns. The condition was common during the static trench warfare in the winter months of World War I and became known as trench foot. The same term has been applied to the lesion in World War II. Trench foot is caused primarily by exposure of the feet to wet cold. Freezing temperatures are not necessary. The injury can be expected when the night temperature drops to 35° F. or below. The necessary duration of exposure varies inversely with the degree of cold. The injury may become manifest after five or six days of exposure or it may appear overnight.

Several factors contribute to the effectiveness of cold in producing the injury. Wet shoes and socks promote loss of heat from the feet by conduction and by evaporation. Mechanical impediments to the circulation of blood in the lower extremity aggravate the effects of reflex vasospasm in response to cold and destroy the body's most effective means of keeping the feet warm. The wearing of tight shoes and leggings, prolonged dependence, inactivity and resting in cramped positions are all predisposing factors. Cold and ischemia exert their effects upon the small blood vessels and nerves and possibly upon the germinal layers of the epidermis.

Immersion foot is similar to trench foot and is indistinguishable from it clinically. It is seen among survivors exposed to wet cold in lifeboats or on life rafts. The causes, both primary and contributing are identical with

those of trench foot. The condition should be distinguished from the nutritional edema and neuritides that occur among survivors from sinkings in tropical waters although some element of nutritional insufficiency may be combined with the effects of cold in ordinary cases.

Three clinical stages of the reaction to injury are recognized. During the first or pre-inflammatory stage the soldier complains of cold numbness and mild pain in the foot and ankle. Slight swelling is the rule when there has been intermittent warming. The second or inflammatory stage begins when the shoes are removed and the foot dries and becomes warm. The pain then becomes tingling in character and more intense. The appearance of the skin changes from a wrinkled surface of white or blue color to that of a smooth red blush. Swelling begins and progresses rapidly so that the shoe cannot be replaced. Blisters may appear during the next twenty-four hours. They generally contain clear fluid but at times the fluid is bloody. Tender areas of ecchymosis appear in the skin of the dorsum or other parts of the foot and these may progress to frank gangrene. The gangrene extends for varying depths and may involve only the superficial layers of the skin or the entire thickness of the foot. The inflammatory stage generally lasts two to four weeks by which time the edema has subsided and the redness has disappeared. The skin is now pale and waxy white. Rarely it is pigmented. It is of delicate texture has begun to sweat and is moderately or abnormally cold to touch. This is the postinflammatory stage. In some cases hyperhidrosis and abnormal sensitivity of the feet to temperature changes develop. Pain is no longer tingling in character but is deep seated and is similar to the pain of rheumatoid arthritis particularly about the first metatarsophalangeal joint. It is usually worse at night and it changes with the weather.

The postinflammatory stage varies in duration and offers the greatest problem in treatment. Many soldiers can be returned to duty within six weeks and the majority within twelve weeks. In about 90 per cent of the cases however so much fibrosis and atrophy will have been incurred in the ligaments and muscles of the foot that even

after six months of treatment the men are unable to perform any but the lightest duties. In some cases the hyperhidrosis and oversensitivity to cold appear to be permanent.

**Prevention**—Education is of first importance for the prevention of trench foot. The soldier must be repeatedly instructed in principles of foot hygiene. He must be taught methods of keeping the feet warm and dry under adverse conditions. A daily change to dry woolen socks is recommended. Extra socks are carried or supplied daily. Above all he is instructed not to go to sleep at night with wet socks and foot gear. Every effort is made to stimulate the circulation in the feet. This is accomplished by foot exercises by avoiding dependence and by massage at the time the feet are dried and socks changed. The shoes and leggings must fit loosely at all times. Cramped positions and immobility are avoided. The clothing must be designed to prevent heat loss from the body in general yet to minimize the collection of perspiration during activity.

**Treatment**—During the first and second stages absolute bed rest is maintained to avoid further trauma to already injured tissues. Heat in any form is strictly avoided. The feet are kept slightly elevated if the position is tolerated and exposed to a cool atmosphere. The optimum temperature of the skin is between 65° and 70° F. and may be achieved with the help of an electric fan and if necessary with a spray of water from the fan blades. Some have advocated extreme cooling with slow elevation to room temperature. The evidence is as yet insufficient however to warrant acceptance of the procedure.

The pain associated with the disease has not been relieved consistently by block of the lumbar sympathetic chain or by actual lumbar ganglionectomy. Sympathectomy is recommended when there is objective evidence of deficient circulation with actual or impending gangrene. Amputation of gangrenous parts is delayed as long as possible. The inflammatory reaction of the second stage of the disease must not be confused with the cellulitis of infection.

Rehabilitation is an important part of therapy. Foot and vascular exercises are taught the patient. Physiotherapy and foot

## VII. TENDONS, TENDON SHEATHS AND FASCIAL SPACES

### INFECTIONS OF THE TENDON SHEATHS OF THE HAND AND OF THE FASCIAL SPACES OF THE PALM

#### TENDON SHEATH INFECTIONS

Tendon sheath infections usually result from direct inoculation of a tendon sheath by a penetrating object or from extension of infection in the subcutaneous tissues.\* Direct inoculation can occur during incision for drainage of a felon but extension to the

through any sheaths that communicate with the one first involved destruction of the tendon and its synovial sheath ensues in a very short time unless the infected space is adequately drained and secondary infection avoided

The flexor tendon sheaths of the index middle and ring fingers extend from a point just distal to the distal flexion crease of the fingers to a line closely approximating the distal flexion crease of the palm (Fig 44). They lie in close apposition to the palmar surface of the phalanges and are separated from the bone only by a thin layer of connective tissue. An infection of the flexor sheath of any of these fingers makes itself evident very promptly by pain swelling in ability to extend the finger completely (Figs 45-47) and by tenderness which corresponds definitely and accurately to the anatomical outline of the tendon sheath.

The sheath of the long flexor of the thumb begins at a point slightly distal to the distal flexion crease of the thumb surrounds the flexor pollicis longus in the palm and terminates a thumb's breadth above the anterior annular ligament (Fig 44). Over the first metacarpal bone it lies between the flexor pollicis brevis and the adductor obliquus. The motor branch of the median nerve to the muscles of the thenar eminence as it arises from one of the digital branches to the thumb at a variable distance (from 1 to 2 inches) below the wrist lies superficial to the tendon sheath. The radial bursa is the proximal portion of the sheath of the flexor pollicis longus is denoted ends in a blind pouch whose posterior portion rests on the pronator quadratus and is separated by the latter from the wrist joint and the radio-ulnar joint.

The sheath of the flexor tendons of the little finger begins just distal to the distal flexion crease of the fifth finger and extends proximally to become continuous in the majority of cases with the ulnar bursa a good sized sac whose posterior wall in the palm lies over the metacarpal bone of the

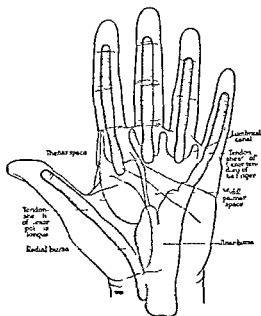


Fig 44—Diagram showing the position and extent of the flexor tendon sheaths and of the fascial spaces of the palm (After Karsavel)

tendon sheath almost never occurs as a result of paronychia or of infections of the dorsal surface of a digit. Since infection spreads rapidly throughout the extent of the closed tendon sheath and secondarily

\*The author has seen only two cases of metastatic pyogenic infection of a flexor tendon sheath one of the flexor tendon sheath of the index finger in a woman with acute rheumatic fever and multiple involvement of the joints the other of the ulnar bursa and common flexor sheath above the wrist in a four year-old girl convalescing from an attack of measles

ring finger and the base of the middle metacarpal bone. Like the radial bursa the ulnar bursa extends proximalward under the an-

pushed radialward, as it were, in three pockets—one superficial to the tendons, one between the superficial and deep tendons



Fig. 43—Infection of the flexor tendon sheath of the index finger resulting in diffuse swelling of the entire finger, more marked on the dorsal aspect. The finger is held in the characteristic position of semiflexion. A small and ineffectual incision, which does not extend to the affected sheath, has been made on the radial side of the finger.

terior annular ligament approximately a thumb's breadth above the ligament (Fig. 44). Its posterior wall lies underneath the flexor tendons, on the pronator quadratus

and one, the largest and most easily distensible, underneath the deep tendons. The exact arrangement of the flexor tendon sheaths in the proximal portion of the palm



Fig. 46—Infection of the middle palmar space secondary to an infection of the flexor tendon sheath of the middle finger.

muscle, and separated by the muscle from the wrist joint. In the region of the wrist joint the ulnar bursa forms a more or less complete sheath for the flexor tendons, being

and over the wrist is subject to some variation, but the important fact, from a practical standpoint, is that in the majority of cases the radial and ulnar bursae communi-

cate with one another. As a result an infection arising in the tendon sheath of the fifth finger involves the same structures in the

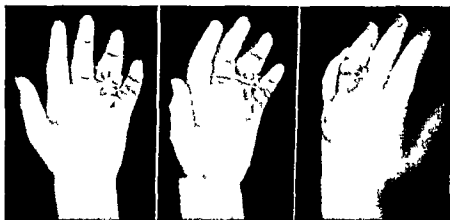


Fig. 47—Infection of the middle palmar space secondary to a neglected infection of the flexor tendon sheath of the ring finger. In this case pus is passing to the dorsum of the hand in the subcutaneous tissue distal to the web between the ring and little fingers.

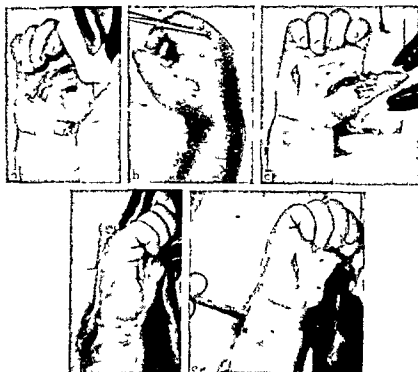


Fig. 48—Neglected infection of the tendon sheath of the flexor pollicis longus which has spread into the forearm and into the ulnar bursa above the wrist. Because it was difficult to be certain if the infection had passed distalward into the palm along the flexor tendon sheath of the fifth finger the first incision was made over the ulnar bursa in the palm (c). The shining tendon could be seen through its synovial covering so the sheath was not opened. a and b Before operation, c, d and e appearance of the hand and forearm immediately after incising the palm over the ulnar bursa draining the retroflexor space above the wrist through an incision on the ulnar side of the forearm (d) and draining the sheath of the flexor pollicis longus and the radial bursa in the palm.

and radial bursa usually extends to the ulnar bursa and distally along the tendon sheath of the little finger (Fig. 50), and an infec-

reverse order. From these various sites infection may extend to a number of different places, as will be indicated later.

**Diagnosis.**—The diagnosis of a tendon sheath infection is based on symptoms which, early in the course of the infection are limited to the area involved but which tend very quickly to become more difficult of interpretation because of extension of the infection to surrounding tissues. The symptoms are pain, tenderness, and other signs of inflammation frequently out of proportion to the extent of the infected area. The patient holds the affected finger in a slightly flexed position (Figs 45-47). Any attempt to extend it causes him to wince with pain. By gentle pressure an area of tenderness can be outlined which corresponds accurately to the anatomical out-

line of the tendon sheath. The freedom from pain on gentle flexion and extension of the finger show that the infection has not yet penetrated the sheath. If such a finger is incised promptly and adequately with care not to carry the incision and the infection into the perhaps exposed but still undamaged sheath the patient recovers rapidly and the more serious condition a suppurative tenosynovitis is avoided. If as occasionally happens as a result of a deep knife cut a tendon sheath is opened and infection of the tendon sheath follows the wincing pain on attempted extension of the finger is lacking because the exudate is no longer held under tension in a closed space. The other characteristic symptoms



Fig. 49.—Infection of the sheath of the flexor pollicis longus, radial bursa, ulnar bursa and sheath of the little finger secondary to a trivial injury of the thumb. (See also Fig. 36.)

line of the tendon sheath. In every case the dorsum of the affected finger is swollen and edematous (Figs 45-47) because of the direction of lymphatic drainage and the greater distensibility of the tissues of the dorsum of the hand as compared with those of the palmar surface.

Of these symptoms the diffuse symmetrical swelling of the entire finger and the wincing pain which results from even a slight effort toward extending the finger are particularly significant. Not infrequently one sees infection of the subcutaneous tissues of the palmar surface of a finger which causes acute pain and tenderness with considerable swelling and which immediately suggests the possibility of infection within the tendon sheath. In such cases the asymmetrical character of the swelling and still more

however, and careful examination of the wound should make the diagnosis clear.

If the infection involves only the index, middle or ring finger there should be no doubt as to its location and the freedom of other fingers from infection. With infection of the radial and ulnar bursae the inflamed swollen wrist (Figs 48 and 49), with the tense anterior annular ligament drawn like a taut cord across its volar surface suggests at once the extension of the infection into the forearm. Since in more than 80 per cent of cases the radial bursa communicates with the ulnar bursa above the wrist it is common to find involvement of both. In early cases however it may be difficult to determine whether one is dealing with one of the less common types in which the bursae do not communicate with



one another. If for example the infection has begun in the thumb and spread into the radial bursa one may be uncertain whether the ulnar bursa and the tendon sheath of the fifth finger are involved. In such a case the position in which the fifth finger is held, the presence of pain on attempted extension of the finger and the

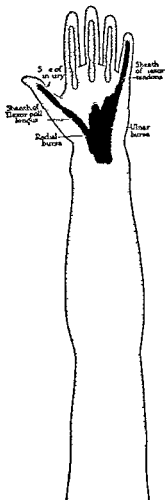


Fig. 60.—Same case as shown in the previous figure. Diagram showing the site of injury and the extension of the infection. The stippled area indicates the extent of the intense inflammatory reaction on the solid black area, the site of abscess formation.

presence of a point of maximum tenderness where the distal flexion crease of the palm crosses the flexor tendons of the fifth finger (Kanavel's sign) are important considerations. If one is still in doubt it is wise through a bloodless field to make an exploratory incision over the ulnar bursa in the palm (Fig. 48). If no infection is present within the bursa the subcutaneous tissues have a normal appearance and more

deeply one can see through the synovial sheath the shining tendon moving back and forth with movement of the finger. If infection is present within the bursa the subcutaneous tissues are edematous and swollen. When the bursa itself is exposed a characteristic change is immediately apparent. The synovial sheath is no longer translucent but grayish white and opaque. The distended bursa usually bulges into the field and the moment it is nicked with the knife blade pus escapes into the field. If no infection is present within the bursa and the incision over it is made first of all before instruments and operative field are contaminated no harm will be done by such a procedure but irreparable injury may be done to the tendon if an infected sheath is not drained. If the primary infection involves the tendon sheath of the fifth finger, the same considerations apply in a reversed order with reference to the radial bursa and the flexor tendon sheath of the thumb.

In cases which have been neglected for four or five days or which have been drained inadequately the median and ulnar nerves may be so compressed by the pressure of the exudate above the wrist as to be partially anesthetized. In such cases the characteristic symptoms mentioned above—particularly the excruciating pain caused by attempted extension of the affected finger—are masked but the history, the location of the primary lesion, the bulging swelling above the wrist and the general symptoms of severe infection make the diagnosis clear.

When rupture of the tendon sheaths of the index, middle or ring fingers takes place the pus spreads into one of the fascial spaces of the palm and forms an abscess of the thenar space or the middle palmar space (Figs. 44 and 50). (These will be discussed under infections of the fascial spaces.) When rupture takes place from the radial or ulnar bursa the pus at first lies in the retroflexor space between the flexor tendons and the pronator quadratus (Fig. 51). As it spreads upward it dissects between the superficial and deep flexor muscles and tends to become superficial along the ulnar side of the upper third of the forearm. In such an event the entire hand and forearm are dusky red, swollen, tense and edematous. Vesicles or blebs may cover large areas of the affected

extremity. Because of the extent of the involvement and the retention of a large amount of pus under pressure toxic absorption proceeds at a rapid rate and the general symptoms of severe infection—high

fever, rapid pulse, profuse perspiration, prostration and not uncommonly delirium—indicate the extreme gravity of the condition.

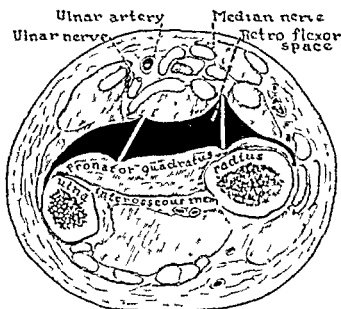


Fig. 51—The retroflexor space above the wrist into which pus ruptures from a distended radial or ulnar bursa (After Kanavel)

fever, rapid pulse, profuse perspiration, prostration and not uncommonly delirium—indicate the extreme gravity of the condition.

monly occurs as the result of extension from a tendon sheath.

The thenar space (Figs. 43 and 52) lies upon the adductor muscles of the thumb

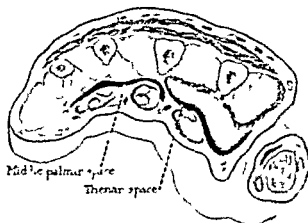


Fig. 52—Cross section of the palm just proximal to the metacarpal bases, showing the position of the thenar and middle palmar spaces (After Kanavel)

#### INFECTION OF THE FASCIAL SPACES OF THE PALM

The important fascial spaces of the palm are the thenar space, the middle palmar space and the lumbrical canals which extend

distalward from the thenar and middle palmar spaces along the lumbrical muscles. Infection of the fascial spaces of the palm may occur by direct inoculation as the result of a penetrating wound but most com-

bone The middle palmar space (Figs 44 and 52) lies deep in the palm underneath the flexor tendons of the middle and ring fingers Its floor is formed by the volar interosseous muscles and metacarpal bones On the radial side it extends to the middle metacarpal bone On the ulnar side it is partially covered by the distal end of the ulnar bursa

Tendon sheath infections arising in the index finger tend to rupture into the thenar space Tendon sheath infections arising in the middle and ring fingers usually rupture into the middle palmar space In neglected cases tendon sheath infection starting in the thumb may rupture into the thenar space and tendon sheath infections arising in the fifth finger into the middle palmar space but such an event is very uncommon

With infection of the middle palmar space the striking symptoms are the loss of the normal convexity of the palm and the edema and swelling of the dorsum of the hand (Figs 46 and 47) Because the pus lies under the firm palmar fascia and under the flexor tendons the palmar swelling is not pronounced but it is sufficient to change the normal convexity of the palm into a slight convexity Because of the direction of lymphatic drainage the dorsum of the hand is swollen and edematous but pus is not present on the dorsum except in neglected cases in which the infection has extended distward along the lumbrical canals and passed to the dorsum of the hand in the subcutaneous tissue about the web of the fingers (Fig 47) Only in grave neglected infections in which osteomyelitis has taken



Fig 53—Infection of the thenar space Note the swelling over the dorsum between the thumb and index finger the forced abduction of the thumb from the palm *c* Incision for draining the thenar space *d* desired the incision can be made in a direction parallel to the web margin instead of vertically

With pus under great tension rupture from one space into the other may take place

The symptoms of thenar space infection are pain tenderness and swelling of the thenar area both on its palmar and dorsal aspects Normally the thenar eminence is the most prominent portion of the palm but with infection in the thenar space it stands out in such a pronounced fashion as to elevate the thenar eminence still more above the remainder of the palm and force the thumb away from the hand (Fig 53) The dorsum of the web between the thumb and index finger is swollen and edematous Eventually there is extension of the infection along the lumbrical canal on the radial side of the index finger with tenderness and swelling on the dorsum of the hand between the index and middle fingers

place does pus find its way directly through the barrier of deep fascia interosseous muscles and metacarpal bones from palm to dorsal surface

#### THE EXTENSOR TENDON SHEATHS

The extensor tendons are enclosed in synovial sheaths only where they pass underneath the dorsal carpal ligament The six compartments underneath the ligaments are lined with a synovial membrane whose visceral layer furnishes a covering for the tendons These sheaths particularly those of the extensors of the thumb are not infrequently the site of a low grade infection which makes itself evident by local pain and tenderness exaggerated by movement of the affected tendons and by a soft palpable crepitation as the tendon moves back

and forth in its sheath. They are not commonly the site of a suppurative inflammatory process.\*

#### TREATMENT OF TENDON SHEATH AND FASCIAL SPACE INFECTIONS

The treatment of infections of the tendon sheaths and fascial spaces is to secure adequate drainage as soon as the condition is recognized. This should be done under a general anesthetic such as nitrous oxide, ethylene or ether, and through a bloodless field secured with the aid of a constrictor.

In draining the tendon sheaths of the fingers the incision should be made well to the side of the finger (Fig. 51), to avoid

dorsalward and not lifted palmarward as the tendon sheath is sought for.

To expose the tendon sheath it is necessary to retract well the edematous and swollen subcutaneous tissue which overlies the tough and inexpandible fibrous tendon sheath. If one can then expose the synovial sheath for a little distance before incising it one will find, instead of a thin translucent membrane through which the shining tendon may be discerned, a grayish edematous structure which resembles the edematous peritoneum overlying an appendiceal abscess. The moment it is opened the pus pours out. In very early cases the pus may be confined to the space underneath the

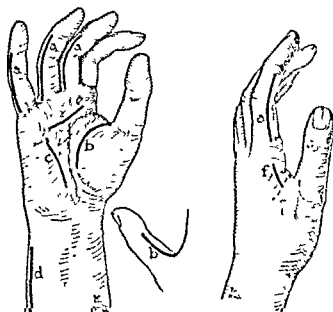


Fig. 51—*a*, Incisions for draining the digital sheaths, *b*, the sheath of the flexor pollicis longus, *c*, the ulnar bursa in the palm, *d*, the retroflexor space above the wrist, *e*, the middle palmar space, *f*, the thenar space.

the flexion creases on the palmar surface and to prevent herniation of the tendon from its sheath, a complication that occurs very promptly if the sheath is opened through a midline incision. The digital nerves and blood vessels should be sought for immediately after the skin incision is made and drawn to one side. Since the digital vessels lie lateral to the nerve and slightly dorsal to it, they are safe from injury if both nerve and vessels are retracted

tendon and appear only when the tendon is gently lifted from the sheath.

If the flexor sheaths of the thumb and little finger are involved the four incisions indicated in figure 51 should be made. One should avoid cutting through the muscles of the thenar eminence in the case of the thumb by making a curved incision to the ulnar side of the thenar eminence (Fig. 48, *c*) and retracting the thenar muscles radialward. The digital nerves to the thumb should be visualized and injury to the nerves carefully avoided. Division of the motor branch to the thenar muscles results in thenar atrophy and loss of the ability to rotate the thumb so that it faces the fingers.

\* The writer has seen only two cases in ten years. One followed a penetrating wound from a fish back; the second a dog bite. In the second case because drainage was not instituted promptly, the infection spread over the entire metacarpus underneath the extensor tendons and dorsal aponeurosis.

In incising the ulnar bursa in the palm (Fig 48 c) one should remember that the flexor tendons of the little finger run obliquely upward and radialward and not in the line of the fifth metacarpal bone and that the digital branches of the ulnar nerve to adjacent sides of little and ring fingers lie superficial to the flexor tendons and their synovial sheaths. The incision in the forearm to drain the upper most distensible portions of the ulnar and radial bursae and the retroflexor space should always be made at the side of the forearm (Fig 48 d), never over the middle of the volar surface for the pus lies underneath the flexor tendons (Fig 51). Incision over the volar surface of the forearm to drain the retroflexor space inevitably leads to extensive fibrosis and destruction of tendons and frequently to injury of the median nerve. An incision on the ulnar side alone is adequate for drainage of both bursae; it should be made as close as possible to the volar surface of the ulna so as to avoid injury of the overlying ulnar vessels and nerve.

The middle palmar space is drained through an incision along the distal flexion crease of the palm (Fig 54). This incision as Bunnell and others have pointed out avoids the risk of leaving a palmar scar transverse to the lines of skin cleavage as a possible cause of a flexion contracture. The flexor tendons, digital nerves and blood vessels of the middle finger are retracted to the radial side and the corresponding structures of the ring finger to the ulnar side. The middle palmar space as it lies behind the flexor tendons is then widely exposed. Through the incision indicated for drainage of the thenar space (Fig 53) a pair of forceps or Kocher dissector can be passed upward and ulnarward directly into the abscess cavity as it lies on the adductor muscles of the thumb.

If drainage incisions are located correctly and of adequate length an incision on one side of the affected fingers and on the ulnar side of the forearm in the case of ulnar and radial bursae infections suffices for drainage. The use of through and through drainage above or underneath a flexor tendon should be carefully avoided. It is the surest possible method of causing necrosis of the tendons.

With infections of the middle palmar and thenar spaces drains should never be inserted through and through from the palm to the dorsum of the hand. The spaces in question are separated from the dorsal surface by a number of anatomical layers (Fig 52). Plunging a pair of forceps through the deep volar fascia, the interosseous muscles between metacarpal bones and through the dorsal aponeurotic and subcutaneous layers in order to drain an accumulation of pus in one of the fascial spaces of the palm renders almost certain the development of osteomyelitis and the formation of persistent sinuses.

#### AFTER TREATMENT OF TENDON SHEATH AND FASCIAL SPACE INFECTIONS

In order to stop venous oozing after operations and to keep wound edges widely separated drainage wounds are packed lightly with gauze impregnated with petrolatum. Occasionally rubber tissue is used instead. Drainage tubes are never used be-

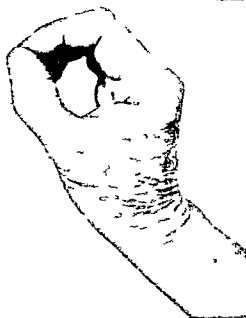


Fig 53—The position of incision (Kanavel)

cause pressure necrosis of tendons and tendon sheaths and extensive fibrosis involving tendons and nerves inevitably result from their use.

After bleeding has been arrested a large sterile towel is laid on the arm board covered with abdominal pads and sterile dress-

ings, and the outstretched arm is laid on the bed of dressings. More dressings are added to cover the arm; the dressings are saturated with warm, sterile boric or salt solution and the edges of the towel brought together over the whole. The warm solution is added at two-hour intervals without changing the dressing, and a powerful electric light or an electric heater is placed above the arm to help maintain the warmth.

At the end of twenty-four hours the dressings and drains are removed and a sterile dressing is reapplied with the same care that was used in applying the original dressing. If one can avoid adding secondary infection, particularly to streptococcal infections of the tendon sheaths the tendons may be saved and a complete restoration of

in the bath the patient is urged to move his fingers gently to prevent the formation of fibrous adhesions. Simply moving the fingers once or twice daily through as complete a range of motion as can be accomplished without pain suffices to prevent the formation of crippling adhesions. As soon as the intermittent soaking and smaller dressing can be substituted for the continuous wet dressing a light aluminum splint is applied outside the dressings to maintain the hand and the fingers in the position of function (Fig. 55). When the danger of lighting up the infection has passed, physical therapy and active exercises are begun so that restoration of function may keep pace with the healing of the tissues. If this ideal is kept in mind the disability that so fre-



Fig. 55—Same case as shown in figure 49 showing the degree of function present nine months after operation.

function secured in a considerable proportion of cases.

No drainage material is reinserted after removal of the original drains. Repeated introduction of a drain almost certainly adds further infection to the open wound.

As soon as the acute symptoms have subsided, usually at the end of three or four days, an arm bath, used for fifteen or twenty minutes twice daily, is substituted for the continuous moist dressing. After being soaked in a warm, sterile solution the arm is laid on a sterile towel, allowed to dry for a half hour under an electric light and then covered with a dry dressing or with a thin moist dressing covered by dry dressings. Care is used to make the dressing large enough to prevent wound secretion from saturating it, but not so large as to cover the tips of the fingers and render their movement impossible. While the hand is

quently continues long after the infection is overcome and the drainage wounds have healed can be reduced to a minimum (Fig. 56).

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## TUBERCULOUS TENOSYNOVITIS

Tuberculous tenosynovitis is a specific chronic infection of the bursae and tendon sheaths of the hand and foot.

**Etiology.**—It is slightly more frequent among females than males, is most often seen in young adults and adults and involves the right hand more than twice as frequently as the left. The disease is usually primary, and it is unusual to discover active tuberculosis elsewhere. Except for the actual inoculation of tendon sheaths, it is difficult to prove or disprove a traumatic origin, and although many patients associate the disease with injury, the tendency today is to question seriously any causal relationship. Adams, Jones and Marble have called attention to the reduced incidence of the disease in butchers since the decline of bovine tuberculosis and the enforcement of stricter pure food laws.

**Pathology.**—*Localization.*—The radial and ulnar bursae of the hand are the most frequently involved; next in frequency are the dorsal tendon sheaths of the hand, then the digital sheaths of the index, middle and ring fingers and last the tendon sheaths on the dorsum of the foot. The radial and ulnar bursae are always infected together, but their distal prolongations into the thumb (frequently) and little finger (rarely) may remain free from disease. The process is so rarely bilateral that the presence of such involvement practically excludes tuberculosis.

**Gross Pathology.**—The sheaths may be but slightly thickened and injected and contain a moderate amount of yellow serous

fluid. More often, however, both parietal and visceral layers are thick and shaggy (Fig. 57) and the enclosed tendons are gray and lusterless while in the small amount of yellow fluid are fibrin flakes and rice bodies. There may be extensive formation of granulation tissue with erosion and destruction with or without rice body formation. As the disease progresses the tendons are invaded and in fully 75 per cent of cases serious tendon destruction will be found and in some 50 per cent whole segments of tendon will be destroyed or so badly fragmented as to require removal. In neglected cases the associated structures—bones, joints and muscles—are invaded and cold abscesses form with their attendant danger of secondary infection. The median nerve though compressed and swollen is never infiltrated.

The rice bodies or melon seed bodies found in about 50 per cent of cases are small shiny grayish ovoid or kidney shaped flattened or faceted masses varying in length from 1 to 15 mm., and in number from one or two to many hundreds. They are probably the result of the mechanical action of the moving tendons on fibrin encrusted products of necrosis of the tendon sheath.

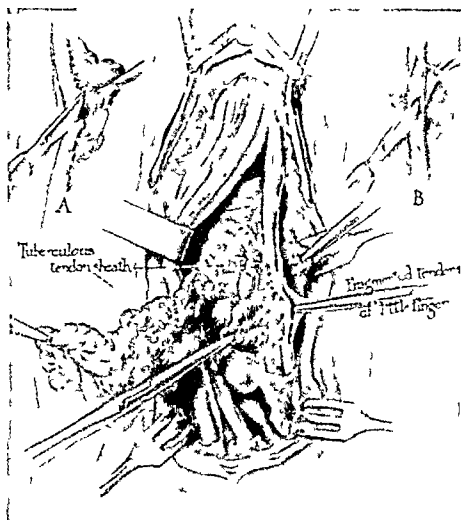
**Symptoms and Course.**—The disease is characterized by the insidious development of a slowly progressive painful or painless swelling over the anatomic area of the involved sheaths (Fig. 58). In one third of the cases the swelling is preceded by sensory or functional disturbance, such as paresthesia, numbness or prickling sensations or by stiffness in one or more fingers. These premonitory symptoms may persist for many weeks or months before the actual swelling appears. A leathery crepitus as in traumatic tenosynovitis may occasionally usher in the tuberculous process.

The swelling often appears as a sudden diffuse edema which responds to heat and rest only to be replaced later by the more tense localized swelling. With involvement of the radial and ulnar bursae the swelling begins at the wrist and extends slowly into the palm whence it may proceed down over the volar surfaces of the thumb and little finger. With involvement of the digital sheaths of the index, middle and ring fin-

gers the swelling first appears over the proximal phalanx and then extends upward into the cul-de-sac of the sheath in the palm. In cases of long standing the disease spreads beyond the limits of the sheaths and leads to swellings in the middle palmar space, thenar space or fascial spaces of the forearm.

to seek relief by the application of heat or cold. After persisting for several months or a year the pain usually subsides even though the swelling slowly increases.

In the early stages of the disease the patient has good use of the part except for the associated pain. Stiffness, weakness and difficulty in closing the fist soon develop





useless and the formation of cold abscesses and secondary infection may necessitate amputation and threaten the patient's life.

**Examination**—Tuberculous tenosynovitis produces a fusiform swelling (Fig 58) which in the early stages may not be apparent unless compared with the sound side. The swelling at the wrist is incompletely divided into a proximal and distal half by the transverse carpal or dorsal carpal ligament (Fig 58 *b* to *e*). On the dorsum of the wrist the several longitudinal compartments can be made out corresponding to the dorsal tendon sheaths. Disease of the digital sheaths produces a swelling resembling spinar ventosa. If rice bodies are present they give a sensation resembling lead shot in a leather bag and produce a peculiar

scopic pathologic picture so closely resembling that of tuberculosis that the differentiation is very difficult. There may occur an acute or subacute inflammation in the early secondary stage and the luetic hygroma and chronic gummatous type in the tertiary stage. The condition is likely to be bilateral, is rarely painful and causes few or no functional symptoms. The diagnosis is established by the presence of associated lesions, a positive serum reaction and response to specific therapy.

Gonorrheal tenosynovitis occurs most often in males, is metastatic, secondary to a urethral infection or more rarely to a vaginitis or ophthalmitis and may follow instrumentation. The onset is acute (rarely insidious) with rapidly developing pain and

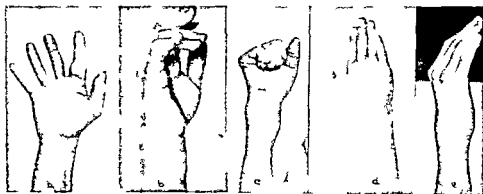


Fig 59—Tuberculous tenosynovitis. *a* Of tendon sheath of index finger. *b* of radial and ulnar bursae and tendon sheath of index finger. *c* of radial and ulnar bursae. *d* of radial and ulnar bursae with rupture into tenar space. *e* of dorsal tendon sheaths.

grating crepitus when the patient is asked to move his fingers. A moderate amount of atrophy of the associated muscles occurs. There is little or no increase in the temperature of the part and the skin is normal unless cold abscesses, sinuses or infection are present.

**Diagnosis**—Tuberculous tenosynovitis must be differentiated from other forms of chronic tenosynovitis and from tumors of the tendon sheaths.

Chronic non-specific tenosynovitis produces a clinical and gross pathologic picture so closely resembling that of tuberculosis that microscopic section is required to make the diagnosis. Bilateral chronic tenosynovitis is almost always non-specific.

Syphilitic tenosynovitis is very rare and may produce a clinical gross and micro-

scopic pathologic picture so closely resembling that of tuberculosis that the differentiation is very difficult. There may occur an acute or subacute inflammation in the early secondary stage and the luetic hygroma and chronic gummatous type in the tertiary stage. The condition is likely to be bilateral, is rarely painful and causes few or no functional symptoms. The diagnosis is established by the presence of associated lesions, a positive serum reaction and response to specific therapy.

Gonorrheal tenosynovitis occurs most often in males, is metastatic, secondary to a urethral infection or more rarely to a vaginitis or ophthalmitis and may follow instrumentation. The onset is acute (rarely insidious) with rapidly developing pain and

loss of function. There is produced a very tender swelling over the course of the tendon sheath with little or no change in the overlying skin. Aspiration of the swelling yields a cloudy, serofibrinous or even purulent fluid. In the early stages rest, heat, plenty of fluids and immobilization of the part in proper splints often lead to rapid subsidence of symptoms. Aspiration of the fluid is helpful but instrumentation and mechanical tampering with the original focus are inadvisable. The immobilization should be maintained no longer than necessary, and it is important to start physical therapy as early as possible.

The common dorsal ganglion produces a tense, circumscribed globoid swelling on the dorsum of the wrist, most often on the

radial side and rarely reaches greater than hazelnut size

Xanthomatous tumor of the tendon sheaths may occasionally lead to confusion when it occurs as a diffuse tumor at the wrist instead of a circumscribed smooth nodular swelling of a finger. It is however firmer and more nodular than tenosynovitis and fluctuation is absent.

Arborescent lipoma is a rare condition in which a fatty branching tumor spreads throughout the sheath. It grows slowly and insidiously and causes few or no functional symptoms. According to Strauss these tumors harden when they have been exposed to cold.

**Prognosis.**—The prognosis for tuberculous tenosynovitis is good; few patients will be found with active tuberculosis elsewhere and unless grossly neglected the local process should not threaten life. If treated early and properly a primary cure should be obtained in the majority of cases but in a few repeated operations will be necessary. The functional results are good though in an occasional case amputation of a digit or an extremity may be necessary.

**Treatment.**—The management should be directed both toward the local lesion and toward the general state of the patient as emphasized by Adams Jones and Marble. The treatment of choice for the local lesion is complete surgical excision of all diseased tissue. If the diagnosis is uncertain the surgeon may temporize for a short time with immobilization and heat but this should not be persisted in after the diagnosis is made. Complete surgical excision is an extensive and time-consuming procedure which if carried out thoroughly justifies all of the pains taken. The operation is performed under a gas (occasionally local) anesthesia in a bloodless field secured by means of a blood pressure apparatus. Appropriate incisions are made avoiding as much as possible midline incisions and incisions crossing flexion creases and great care is taken to identify and isolate all important nerves and blood vessels. The tuberculous sheath is opened and each tendon taken in turn and carefully stripped of diseased tissue after which the parietal portions of the sheath are excised (Fig. 57). Fragmented and diseased portions of tendons must be removed and

it may be necessary to repair tendon defects by means of a suture or tendon graft.

Other less radical procedures are not to be recommended. Partial excisions, simple drainage, simple removal of rice bodies and the injection of iodoform or other emulsions offer by no means the favorable prognosis of thorough excision. Roentgenotherapy deserves serious consideration in those cases in which operation is not feasible or in which radical excision has failed to obtain a cure.

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## INJURIES OF TENDONS

### LUXATION OF TENDONS

Dislocation of tendons from their normal channels may be caused by congenital malformation, deformity, trauma to the restraining ligaments, fracture or arthritis. The symptoms are pain and feeling of weakness and disability due to the fact that the tendon is working at a mechanical disadvantage. The tendons that pull around a bony convexity and from slight abnormality, are prone to dislocate are the extensor of the finger over the head of the metacarpal bone, the long head of the biceps in the bicipital groove, a fascial band which slips over the great trochanter of the femur, the patella, the peroneus longus and brevis, and the tibialis posterior. The tendons which dislocate

vertically from their channels because of defects in their restraining annular ligaments due to trauma or disease are the flexors of the digits the flexors and extensors in the wrist and the dorsal extensors of the foot. Because of an angular deformity at a joint a tendon may dislocate sideways spanning across a joint and so change its function that the motion produced is in a plane at even 90 degrees from the normal. Common examples are the dislocation of the extensor longus hallucis in bunion and of the peroneal tendons in talipes calcaneus. Flexor tendons in the forearm may dislocate over each other with a snapping sound because of their angle of pull and thickening of the paratenon.

**Long Head of the Biceps**—The long head of the biceps may slip forward from the bicipital groove in abduction and external rotation following trauma, congenital malformation or arthritis. There is a painful snap followed by pain, tenderness, weakness and disability in lifting in the forward and abducted positions. The treatment is to fix the tendon to the head of the humerus or to the coracoid process or to reconstruct the groove which has been filled with fibrous tissue by building up the inner bony lip and reconstructing the restraining ligament with fascia. (See section on Muscles and Ligaments.)

**Flexor Tendon of the Finger**—A median longitudinal volar incision in a finger is pernicious as it severs the annular bands or pulleys opposite the centers of the proximal and middle phalanges and the head of the metacarpal and so allows the flexor tendons to spin around the concavity of the flexed finger like bow strings with loss of their mechanical efficiency. A pulley may be reconstructed by encircling the tendon and bone with a free graft of fascia or tendon. Annular ligaments on the dorsum or flexor aspects of the wrist and on the dorsum of the foot can be reconstructed by fascial grafts.

**Extensor Tendon of the Finger**—When an extensor tendon slips off a knuckle it not only deviates the finger to that side but cannot extend the proximal finger joint. The tendon may be held in place by reconstructing the transverse ligamentous tissue with a small fascial graft and also if necessary by transposing the strip of main tendon of the

dorsal aponeurosis which caps the joint to a corrected position in this aponeurosis.

**Snapping Hip**—Occasionally there is a thickened tendinous band on the deep surface of the gluteus maximus which when the knee is flexed and the hip internally rotated can be felt to slip forward over the trochanter of the femur causing annoyance. The remedy is to divide the band and suture it backward from the trochanter.

**Dislocating Patella**—When the line of pull of the quadriceps tendon to the tibial tubercle lies external to its sesamoid bone (the patella) and the outer condyle of the femur does not stand sufficiently forward the patella dislocates outward when the knee is forcefully extended. Considerable disability results. The patient cannot indulge in sports because at any time the dislocation may occur and cause him to fall. Operation must be rather radical and mere fascial graft is insufficient. The whole tibial tuberosity should be chiseled off and displaced inward at least 1 inch and there embedded under an osteo-periosteal flap and sutured with chromic catgut. The ligamentous capsule of the knee on the outer side is slit longitudinally for 3 inches and allowed to gap. On the inner side the capsule is narrowed by dissecting up a similar sized tongue of ligament with its base attached to the tibia. This tongue is then threaded diagonally across the patellar tendon and sutured to the outer corner of the patella and the gap left in the inner side of the capsule is closed by suture.

**Peroneal Tendons**—Starting usually between the ages of eight and twenty years and because of a congenitally shallow groove often bilateral the peroneal tendons either the longus or both dislocate and can be felt beneath the skin over the outer malleolus. The dislocation may first start with a sprain in inversion and dorsiflexion in which the annular ligament is torn or stretched but later it may become habitual and occur at inopportune times. When it first happens pain, tenderness, swelling and ecchymosis result. In recurrences the patient feels something give way and is lame and partially disabled. In talipes calcaneus it occurs without symptoms. In a recent case a felt pad is stripped on with adhesive plaster to retain the tendons in place. The use of a walking cast is advisable until the an-

nular ligament is repaired. A brace may be used to prevent the motions from causing dislocation. In the operative repair the posterolateral border of the malleolus is built up with bone graft or the outer aspect of the malleolus may be so cut out that it can be slid backward in a groove on the malleolus. The annular ligament is then reconstructed by a fascial graft.

## RUPTURE OF TENDONS AND MUSCLES

(See section on *Rupture of Muscles*)

Rupture of tendons and muscles partial or complete occurs as a result of direct trauma especially when under voluntary tension but more frequently indirectly from excessive tension from either voluntary contraction or passive strain. Commonly a direct blow on a contracted muscle belly ruptures the fascia and muscle fibers locally and a blow from an angular object on a tense tendon against a bone may rupture it at once or cause such reaction that delayed rupture occurs from some slight strain several weeks later. Sudden violent muscular contraction against resistance may result in rupture anywhere from the origin to the insertion including less commonly even the tendon itself. The usual sites of rupture in voluntary or passive strain are at the musculotendinous juncture at the origin or the insertion either with or without evulsion of some bone or across the muscle belly itself either partially or completely. In some instances the tears in the muscle are multiple so that the effect is merely a lengthening. Tendons weakened by disease or previous wear and injury frequently rupture. Ruptures are rare in persons under twenty-five years of age and usually occur in the latter half of life when the tissues are brittle and have lost their resiliency and the factors of arthritis and wear have developed. The bones over which the tendons slide may be roughened because of fracture or arthritis and cause wear and fraying of the tendon until it eventually ruptures. Similarly the stress and overuse of tendons and muscles in certain occupations may weaken them until they break. Examples are the muscles of the neck in loaders, the Achilles tendons in mountain climbers, the adductors in equestrians, the extensor longus pollicis in drum-

mers and the long head of the biceps in plasterers. Infectious diseases lead to rupture of tendons and muscles by general weakening of these structures. Other diseases act locally such as tumor, trauma, tenosynovitis either pyogenic gonorrheal or tuberculous, arthritis, lipoma of tendon sheath and trichinosis. Because of the lack of the sense of pain rupture may result in tubes or craniomyelia and from convulsions in epilepsy or tetanus.

**Symptoms.**—A rupture of a muscle may be so mild as to imitate lumbago or stiff neck or if greater may result in hematoma showing as a firm tender painful swelling. Several days later a sulcus can be felt across the muscle. Muscle ruptures cause a sharp severe painful snap or tear and disability, weakness and pain on movement of the muscle which is often referred to the origin or the insertion. The pain from the rupturing of a tendon is but momentary and but little swelling or pain ensues. After the rupture of a tendon or muscle the endervated and retracts and forms a rounded swelling or muscle belly which is extra movable sideways and travels on contraction. The portion of the muscle separated from the nerve supply atrophies.

**Treatment.**—Surgical repair of the tendon or muscle should be prompt before contraction of the muscle and retraction of the tendon become organized and permanent. If for some reason this cannot be done the muscle or tendon ends should be pulled together by applying coaptation splints and the joint splinted in flexion to prevent retraction when repaired later. The regenerative ability in muscles is poor and unless close approximation of their ruptured ends is accomplished scar tissue will intervene and will later stretch out. Sutures cut through muscles so the suturing should be far back and somewhat bridled through the muscle catching the fascial matrix like where possible. Suturing with strips of fascia eventually results in firmer union. The muscle sheath also should be repaired and a gap in the muscle should be bridged by a sheet of fascial graft.

## SPECIAL REMEDIES

**The Extensor Tendon of the Finger.**—Stubbing an extended finger as with a

baseball either avulses the insertion or a small piece of bone with it causing drop or mallet finger. Immediate splinting and keeping the distal joint of the finger in extreme hyperextension and the middle joint in flexion for five weeks will remedy the condition. In such cases suturing is unnecessary. In late cases (two weeks or more) suturing is necessary even if supplying a short tendon graft. Trauma and silk sutures too frequently prevent motion by causing adhesions to the head of the middle phalanx so here removable stainless steel wire no. 35 gives better results. Where the central slip of the extensor tendon is ruptured over the middle joint of a finger resulting in a position of flexion of this joint and hyperextension of the distal joint similar treatment is required.

**Extensor Longus Pollicis**—Rupture primary or often delayed occurs where the tendon passes through its groove on the radius because there it is directly traumatized against the bone cut or worn by a spicule of bone from a Colles fracture or worn from use. The result is a loss of extension in the distal and partial loss in the proximal joint of the thumb so in grasping it will not clear an object. Repair is by means of a short tendon graft or by transferring one of the extensor tendons from the index finger.

**Biceps Cubiti**—Rupture of the biceps cubiti may occur at the insertion lower tendon musculotendinous junctures belly of the muscle tendon of the short head or long head or at the glenoid attachment. The long head is ruptured the most frequently and commonly between the tuberosities of the humerus because of wear thus differing from rupture in the other sites in being usually latent. The combination of degeneration of the tendon caused by senility roughening of the bicipital groove from arthritis and an occupation involving arm raising accounts for the frequency of the wearing fraying and finally rupturing of the tendon at this site. Rupture of the tendon of the supraspinatus as a tear across the capsule of the shoulder joint may also be associated from impingement against the acromion. Ruptures that are not between the tuberosities occur usually in heavy work in lifting or from sudden tension on the outstretched arm.

**Symptoms**—In the latent cases the arthritic like ache in the deltoid region is increased by work and weakness and difficulty in arm raising are noted. If the long head becomes reattached in the groove there may be hardly any symptoms. One function of the biceps is to hold the head of the humerus into the glenoid cavity for proper mechanics. In cases of rupture especially of the tendon of insertion this action is lost and there is much difficulty in raising the arm. There is also weak flexion of the elbow and the contour in the biceps muscle and tendons changes.

**Treatment**—In acute cases immediate suture should be done except in rupture of the tendon of the long head in the joint. Here as in late cases the tendon is usually attached to the head of the humerus in a hole in the bicipital groove or to the origin of the short head in the coracoid process. Rupture of the tendon of insertion is repaired by direct suture to the tuberosity of the radius the removable stainless steel wire suture pressing out the dorsal skin to a button. In late cases a fascial graft is added.

**Supraspinatus Tendon**—Rupture of the supraspinatus tendon is prevalent after middle life and is often preceded by gradual weakness and pain as the tear in the insertion of the tendon may be gradual following impingement against the acromion. In the repair after overstrain lime is deposited in the tendon and may discharge into the subdeltoid bursa which overlies it. Eventually in lifting a sudden tearing may occur resulting in pain and inability to raise the arm. Conservative treatment in mild cases is by means of an aeroplane splint. Surgical repair consists of repairing the tear in the tendon and the shoulder capsule and splinting in abduction. A mere deposit of lime is absorbed after needling by Milgram's method.

**Rectus Abdominis**—Rupture of the rectus abdominis may be caused by lifting and pulling. It also may occur in pregnancy and following septicemia. The local pain tenderness and rigidity may erroneously suggest an intra abdominal condition.

**Quadriceps**—The usual site of rupture of the quadriceps is across the patella extending well into the tendon on each side. The cause is sudden overflexion of the knee or excessive contracture of the quadriceps.

Similarly the tendon of the quadriceps may be torn completely across just above the patella. Rupture may also occur across any part of the gastrocnemius muscle especially in the rectus or across the deep fibers only. More rarely the patellar tendon is torn from its attachment to the broad rough triangular area under the patella. In the young the tibial tubercle may be avulsed instead. The symptoms are immediate pain, swelling, effusion and loss of power to extend the knee. If the rupture is below the patella the *litter rides* upward when the quadriceps is contracted or the knee is flexed and if the rupture is above a sulcus is demonstrable. Treatment is by direct surgical repair uniting the patella by wire or chromic catgut sutures. The rent in the quadriceps tendon should not be overlooked. In late cases of rupture above and below the patella one must resort to fascial grafts.

**Gastrocnemius**—In springing off the ball of the foot a sudden pain may be felt in the calf as some of the fibers of this muscle rupture. There is local pain and tenderness and pain on standing on the ball of the foot. Treatment includes rest, local strapping and raising the heel of the shoe.

**Rupture of the achilles tendon** is fairly frequent and occurs from sudden muscular strain. It may be at the musculotendinous juncture in the middle of the tendon itself or at a point just above the calcaneus or a piece of bone from the latter may be avulsed. A gap can be felt in the tendon and the belly of the calf muscles appears round and retracted upward. Dorsiflexion of the ankle is increased and power to stand on the ball of the foot is lost. Treatment is by direct and immediate suture, all paratenon and shreds of tendon being preserved as essential aids in the repair and splinting with the knee flexed and the foot in the equinus position. In late cases it will be necessary to bridge the gap between the ruptured ends of the tendon with fascial graft.

### SEVERED TENDONS

The tendons in the forearm and hand are usually severed by glass, porcelain, faucets, knife, buzz saws and sharp tools. If severed within a sheath the ends merely round over and remain free but if infection is present they proliferate and attach themselves

If severed within paratenon each end sends out a growth mostly from the paratenon and epitenon an inch or more in length in an effort to become reattached. The two ends may reach each other and then contract reestablishing the tendon or at least motion on the next joint or may become attached to the surrounding tissue thus hampering the action of the muscle especially a common muscle to several tendons.

**Primary Repair**—Before anesthetizing tests should be made for severed nerves and tendons. The tendons should not be sutured in wounds which are very dirty or highly traumatized even if seen early. In most wounds tendon repair may be done up to eight hours but if factors are favorable (clean laceration and no excess of leukocyte or bacteria in smears) it may be done up to twenty-four hours but never after that. Bacteria will have multiplied so that infection will be probable and such infections are crippling.

For tendon repair the limb should be rendered bloodless by winding with an Esmarch bandage 1 inch above this in the upper arm a blood pressure band should be pumped to 300 mm. mercury and the tubes clamped. The Esmarch bandage is then removed.

After the wound has been covered the limb is shaved and thoroughly washed with soap water and benzine. The wound and limb are then painted with 50 per cent tincture of iodine and the wound is immediately blotted to prevent penetration of the chemical. The whole surface of the wound is excised with exquisite care and thoroughness all traumatized and infected tissue and all chemical being removed. It may be rinsed with copious amounts of salt solution. Retracted tendon ends may be recovered through small transverse incisions. All vulnerable structures such as joints, bones and tendons should be covered by skin flaps and the denuded areas by thin skin grafts. The tendons are sutured with a minimum of suture material, silk being used or preferably removable fine stainless steel wire. All handling of tissues should be atraumatic. The wound is then closed usually without drainage and tetanus antitoxin administered. The arm is splinted with the wrist not the fingers in flexion if flexor tendons have been severed and elevated.

Primary tendon suture from the distal part of the palm to the middle finger joints results in failure caused by adhesions unless special precautions are taken. The annular sheaths are slit laterally to allow for swelling during healing. Stainless steel wire being non irritating is used and placed in one tendon end only because a tendon pulls in only one of its ends. The two wires are passed down through the other end and on out through the skin to be anchored there to a button. A pull out wire is looped about the suture and brought out through the skin proximally to withdraw the suture backwards in three weeks when the tendon will be united. The tendon ends are either laid together or approximated with one tiny silk blood vessel suture. Absence of any suture is less irritating than is the presence of silk. The latter after three weeks is but an irritating foreign body. As a further precaution to lessen adhesions at the tendon juncture the suture may be placed at a distance proximal to the juncture as in the palm.

**Late Repair**—Late repair of tendons should be postponed until at least four months have elapsed since the last wound healed for fear of latent infection. All such repairs of the hand or forearm demand a more exacting technic and attention to a host of minute details than does the usual surgical procedure. Rigid asepsis and delicate handling of tissue are essential or else the subsequent tissue reaction will be sufficient to bind the tendons and prevent motion. Such operations should not be undertaken lightly and without thorough preparation as they are often unsuccessful. The problem is usually composite involving in addition to tendons nerves skin and other tissues.

The extensive cicatrix should be excised so that only good tissue remains. If there are flexion contractures of the skin this skin should first be removed and good fat lined skin substituted by means of pedicle grafts in order to improve the nutrition of the limb by relaxation and to provide mobile tissue through which the tendons can move. Joints should be mobilized before tendons are repaired and also nerves should first be sutured so that they can regain their trophic effect on the tissues. Incisions should be so

placed that they do not overlie the tendons and do not cross flexion creases at right angles. All median longitudinal incisions should be avoided lateral ones and those following the natural creases in the skin being used instead.

The pulleys or annular ligaments in the fingers and about the wrist should be reconstructed to prevent the tendons from pulling across the joint and so losing their mechanical efficiency. Tendon repair carried out after two months generally requires free tendon grafts to bridge the gaps because the muscles will have contracted and much of the tendons will have degenerated from disuse. Tendon freeing and tendon transfers are useful but direct tendon suturing can usually be done only in fresh cases. The gliding mechanism for the tendons should be reconstructed as tendons which pass through cicatrix will become scarbound. One should aim to have a minimum of moving parts and a maximum of gliding mechanism. The latter can be obtained by interposing thin fascia between the tendons and the bones or scar tissue with its gliding surface next to the tendon. Thin sheets of paratenon fat which can be obtained from over the triceps tendon or close to the fascial lata can be similarly used. Where possible it is well to transplant a tendon plus its layer of paratenon as a complete gliding assembly. The suturing or juncture of the tendon should be made at the insertion in the finger end or in the palm and forearm where adhesions will do the least harm. A juncture made within a finger will inevitably become fixed in the narrow channel. Therefore damaged tendons should be removed completely from the finger and a new part substituted by free tendon graft together with either the loose tissue surrounding its epitenon or with a sleeve of paratenon. Free tendon ends should not be left in the tissues as they will become reattached and will cause flexion contractures and loss of function.

Tendon grafts can be obtained from the *palmaris longus* from surplus tendons in the hand and forearm such as the *sublimis* and from the long extensors which reach from the lower third of the shin to the toes. The *extensor brevis* will continue to extend the toes. Strips of fascia may also be used as

substitutes for tendons, but these are prone to adhere. Free tendon grafts remain alive as such. Their surfaces and much of their depth subside at first on surrounding lymph and soon acquire a blood supply of their own. Some patchy necrosis occurs within a graft but this eventually becomes substituted by normal tendon tissue. In the first three weeks the graft becomes swollen and edematous but this condition subsides and in three months the graft closely resembles normal tendon both in the gross and microscopically. Practically free tendon grafts

ing to the end with two or three stitches on one side and three or four on the other. The amount of silk showing on the surface is minimal as each needle is reinserted only a few fibers away from where it emerges. With sharp scissors the tip of the tendon grasped by the hemostat is cut off and each needle is then made to re-enter the side of the tendon and emerge from its end. There is thus a non strangling splicing effect over a length of tendon. The two strands of silk are drawn tight to remove all slack and are similarly spliced up the other tendon end which is likewise held taut by a hemostat on its tip. The two strands emerge from the same hole  $\frac{1}{2}$  inch up this tendon. To slide this tendon end down against the other to eliminate slack, first one strand is drawn taut and the tendon is slid down then the other strand is

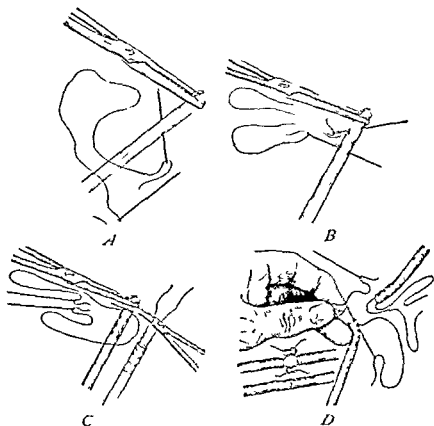


Fig. 59.—Tenorrhaphy. A Tendon grasped and suture started B further steps in suture C traumatized end of suture cut off D method of making end-to-end attachment of tendon ends \*

are successful and even hypertrophy to sufficient size to accommodate the strain. They show some tendency to contract, so they should be long enough to be sutured under slight tension when the origin and insertion are placed at their maximum distance apart.

In suturing tendons with silk the untreated is used or the knots slip apart. The tendon is not handled but is held taut by grasping its tip with a Kocher hemostat. A 10-inch piece of silk with a straight spear-pointed needle threaded on each end is used to splice down one tendon end and up through the other. The needles are passed diagonally back and forth through the tendon starting  $\frac{1}{2}$  inch from the end and work

drawn straight and the tendon again slid down. This snugness keeps the ends from separating when under tension. The two strands of silk are tied together, the single knot being sunk within the tendon at a place where it will have the least tension to avoid breaking. A little rolling fits the ends accurately together. Such junctures become invisible.

When removable stainless steel wire is used no 34 for flexors and no 35 for extensors it is spliced through the tendon end exactly as shown in figure 59 C but in the proximal tendon end only. The needles are then passed up the other or distal tendon end and on out through the skin for anchorage to a button, etc., as described under primary repair. The two ends of the pull-out

\* Bunnell J Bone & Joint Surg 10



wire which is looped about the proximal end of the suture are threaded on a single curved needle and brought out through the skin proximally and left there. In three weeks the button is cut off and the suture is withdrawn proximally by the pull-out wire. By this time physiological union will carry on. There are many other useful methods of placing the wire so that it is removable.

As tendons heal there is in the first week swelling with fibroblastic tissue and in the second week connective tissue bridges the gap but the union is very weak. By the end of the third week tendon strands spin across and furnish moderate strength of union. Exercise up to this point is undesirable as it produces adhesions but it is advisable thereafter. During the fourth week the exercise should not be forceful. During this week the tendon loosens from its surroundings. During the first three weeks strain is prevented by splinting the wrist in flexion in the case of flexor tendons and in keeping the wrist and fingers in extension in the case of extensor tendons. Adhesions are inevitable and greatest in two weeks. Later under stimulus of active exercise more and more motion of the tendons will result. The maximum improvement possible may not be gained for a year.

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#### REFERENCES

may be found also on the volar surface of the wrist on the volar or dorsal surface of the finger on the dorsum of the foot or of the toe on the lateral surface of the knee or in the popliteal space. It is filled with a mucoid material, is usually thin walled and is found in the region of a tendon sheath or a joint capsule. It may occur even in the substance of the tendon. "Carp and Stout" believe it to be due to mucinous degeneration of the capsule of a joint or of a tendon sheath. The studies of De Orsay, McCreary, Jr. and Ferguson<sup>3</sup> suggest that the contents of a ganglion are mucoid rather than mucinous and that the process is one of degeneration of collagen fibers rather than a secretion of connective tissue cells.

Ganglion occurs most commonly in the second, third or fourth decade and it is not unlikely that trauma is an etiologic factor. Pain and weakness are rather common symptoms. According to Mason<sup>1</sup> complete excision is the best treatment. He says:

This must be performed in a bloodless field and by careful dissection. It is not sufficient to remove the cyst alone but the tissues from which the ganglion springs must be excised since they contain other cysts or degenerative areas which are likely to lead to recurrence. Transverse incisions are much to be preferred to longitudinal ones for removal of the carpal ganglia. The transverse incision gives excellent access and since it follows the natural skin folds heals with a minimum of scar and contracture. When the ganglion is accessible as on the dorsum of the wrist dispersion by striking it smartly with a book and massaging the extravasated contents will effect a cure in some cases. Aspiration is practically useless and injection of strong irritants is to be condemned. Sarma<sup>4</sup> has cured 78 per cent of 64 ganglions by aspiration of the bursa and injection of 5 per cent sodium morrhuate.

INDRICK CHRISTOPHER

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## VIII. MUSCLES AND LIGAMENTS

### SURGERY OF THE MUSCLES

The surgery of the muscles includes the following (1) congenital deformities (2) traumatic lesions (subcutaneous or open) (3) inflammations (acute and chronic) (4) muscular changes (atrophy, degeneration, hypertrophy, contracture), (5) neoplasms and (6) parasites

### CONGENITAL DEFORMITIES

It is not uncommon to find cases of congenital absence of muscles. Indeed such an absence may occur on one side of the body and not on the other. Several muscles are so inconstant that their presence or absence is not regarded as abnormal and even such great muscles as the pectorales majores may be partly or totally absent on one or both sides of the body.

### TRAUMATIC LESIONS

Direct and indirect forces produce traumatic lesions which may be subcutaneous or open such as contusions, partial and complete ruptures and hernias. From a pathologic point of view one may differentiate five degrees of muscle injury according to the extent of damage: (1) muscular stupor, (2) fibrillar rupture with hemolytic infiltration, (3) partial rupture with hematoma, (4) complete rupture and (5) mangled.

**Contusion of Muscles**—The damaging force may come from without or within. Violence from without is usually due to falls, blows, kicks or bites of animals (more commonly horses or dogs). Violence from within is due to the displacement of a bone or bones following a fracture or dislocation.

The *symptoms* of a contusion are disturbed function, more or less pain when attempting to use the muscle, with the maintenance of an attitude to relax it, swelling, fluctuation, ecchymosis and hematoma depending on the amount of hemorrhage which has occurred. The extent of separation of the torn ends of a muscle is commensurate with the size and length of the muscle.

The *prognosis* naturally varies. In uncomplicated contusions restoration of function is usually complete in a few days or weeks. If the nerve supplying the muscle is also contused however as frequently happens in the deltoid muscle atrophy and impairment or loss of function of that muscle occur and persist for some time.

The *treatment* at first should consist of rest by immobilization, relaxation, elevation of the affected part if possible and application of external heat followed by massage, a moderate compressive elastic bandage and graduated exercises. Occasionally the nerve may be severed. It is extremely important to be cognizant of this possibility in order to minimize the loss of function by early and adequate treatment.

**Partial Ruptures (Sprains and Tears) and Complete Rupture of Muscles**—These are of frequent occurrence.

**Mechanism**—As early as 1859 Maydl in a comprehensive article analyzed and classified the different mechanical conditions that may cause a muscle to tear and Bruckner and Milch have presented this scheme in outline form as follows:

Muscles tear as a result of

#### I Muscular action

##### 1 Flaccid

- 1 Contraction of antagonist
- 2 Passive stretching

##### B Contracted muscles

- 1 Active contraction
- 2 Contraction of antagonist
- 3 Increase of tearing over cohesive power
- 4 Asynchronous contraction
  - a Inner part against outer (as in bifid muscles)
  - b Distal part against proximal part
- 5 Additional muscular force of another muscle

#### II External trauma

#### III Spiral twists of limb

#### IV Degeneration of muscle as in disease and in neurologic condition



Fig 60—These two photographs were supplied by Drs Everingham and Hitchcock. At left, partial rupture of the medial head of the left gastrocnemius muscle. The belly of the muscle protrudes even when the leg is relaxed. At right the right leg for comparison.\*

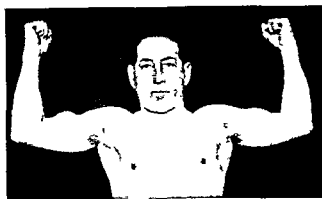


Fig 61—Partial rupture at proximal musculotendinous junction of the long head of the right biceps due to direct trauma. Note the characteristic bulging of the muscle belly.



Fig 62—Partial rupture of right deltoid muscle†

*Sites and Frequency*—The muscles of the calf (Fig 60) come first in frequency, followed by the extensors of the leg, the biceps of the arm (Figs 61-63), the Achilles

tendon and the extensor of the thumb (Grassheim). Maydl collected reports of

\* G. Lecest. JAMA 100

† G. Lecest. Surg. Gynec. & Obst. 68

sixty one cases of tears of the quadriceps muscle and fifty seven of the patellar ligament—in all 118 cases—and 103 ruptures of muscles in the upper extremity (Fig 64) and trunk. When one considers all the cases of back sprains and the so called cases of

jumpers dancers runners mountain climbers and tennis players the extensor pollicis in drum players the muscles and ligaments in and about the elbow joint in tennis players the flexors in the hip of sprinters the rectus abdominis in broad jumpers the back

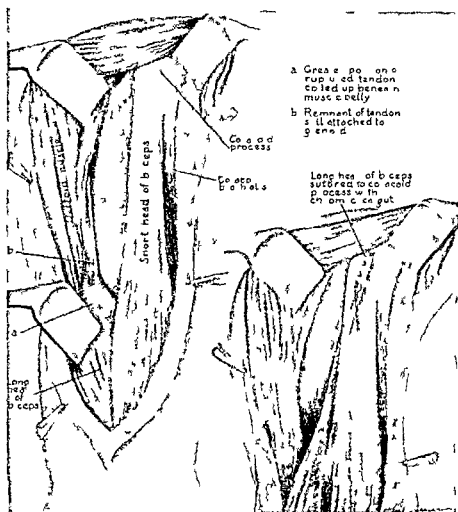


Fig 63—At left the condition revealed at operation—an old intrasubular partial rupture of the tendon of the long head of the biceps. The ruptured tendon was found coiled up like a watch spring under the upper end of the muscle. A small remnant of the tendon is seen which has prevented the bell of the muscle from dropping. At right suture of the long tendon to the coracoid process and to the upper fibers of the short head.

lumbago one must realize that many of these patients actually are suffering from tears in the deep back muscles or fascia.

**Occupation** often is a factor in strains, tears and ruptures of muscles. Of the greatest interest are those lesions occurring in healthy young persons as a result of indirect trauma. The neck muscles usually are affected in load carriers and pickers; the biceps and triceps in pitchers and lifters; the adductors of the thigh in horseback riders; the muscles of the calf in boxers

muscles (latissimus dorsi or sacrospinalis) in golfers and stevedores.

**Fatigue**—Excessive fatigue may render the muscular fibers less likely to resist a sudden and forceful pull or jerk. Roth in his researches noticed experimentally a waxing degeneration of the muscular fibers when the fibers were greatly fatigued and a greater fragility caused by decreased cohesion, elasticity and contractility. If the fatigue is superimposed on old pathologic or

\* Cf. Ernest S. Ferguson, *Obst.* 55.

semile changes the exhaustion and consecutive tear of the muscular fibers are produced more easily.

**Symptoms**—When the rupture occurs through the belly of the muscle each end retracts leaving a gap or hiatus. Immediately the intervening space becomes filled with blood which in turn is replaced by connective tissue thereby forming a bond of union between the ends. Adhesions often occur in the process of repair between the separated muscular ends and the adjacent structures. Often if the rupture of the muscle or tendon is only partial the patient complains of weakness and pain in the nearby joint. If the rupture is in the upper



Fig. 64—Rupture of the biceps brachii in a young man.

end of the biceps he may complain of pain in the shoulder; if in the lower end of the biceps of pain near his elbow joint; if in the muscles of the thigh of pain in his knee. Because of joint pain a patient is often given physiotherapy for months as the attending physician considers that there is a sprain of the joint.

**Diagnosis**—The clinical features are usually characteristic and the diagnosis is not difficult, yet a large number of these cases go unrecognized and untreated for weeks and often months. Suspicion of a ruptured muscle should be aroused immediately when a person complains of having felt a sharp pain during a forceful muscular act or having

heard a sharp snap often audible several feet away of having had the sensation of being struck with a whip and having felt something give way. Immediately the limb becomes weak and often powerless. At the site of the rupture there is tenderness and sometimes swelling and ecchymosis. Often a gap can be palpated.

**Treatment**—If the tear is not extensive the limb should be put at rest and immobilized two or three weeks until union has occurred, then massage and graduated exercise should follow. Partial ruptures of the biceps should be immobilized in acute flexion; those of the calf of the leg should be immobilized by the application of adhesive tape and the person should wear high heels for several weeks. If the rupture is complete or extensive immediate surgical intervention and repair are indicated. Early operation with approximation of the lacerated ends by mattress sutures reinforced if necessary by a piece of fascia from the fascia lata usually will give most gratifying results. If the operation is delayed for weeks or months it is not so satisfactory because of adhesions and the retraction of the ends of the muscle.

**Hernia**—A true muscular hernia is produced by the bulging of a part of an intact muscle through an accidental opening in the fascia. This condition is rare and usually has a gradual onset being the result of a rent in the fascia.

A pseudomuscular hernia is produced by the bulging of an intact or ruptured muscle through its sheath. This condition occurs frequently, is of sudden onset and is accompanied by sharp pain.

**Diagnosis**—Aside from the slow onset the tumor of a true muscular hernia decreases or disappears when the muscle is actively contracted or passively extended while that of a pseudomuscular hernia increases.

**Treatment**—A true hernia requires surgical intervention only if it causes inconvenience. Incision and repair of the rent usually suffice with occasional excision of the herniated portion (partial myectomy). A pseudohernia always should be repaired.

**Open Injuries**—A damaging force may produce an incised, lacerated, contused or penetrating wound. The prognosis and treat-

ment of these wounds are dependent on the extent of the injury, the presence or development of inflammation and the degree of functional disturbance. The more contused the edges, the more probable is the development of infection. Superficial punctured or gunshot wounds usually heal promptly unless foreign substances are carried deep into the tissues. Then they become the most serious of wounds. Such wounds should not be probed. Recent clean wounds should be sutured in layers. An untreated wound seen for the first time after several days should not be closed but should be treated as a contaminated or infected wound. Severely contused or mangled wounds should be debrided thoroughly. The use of chemotherapeutic agents (sulfonamide, penicillin) is of advantage not only for combating infection but also for its prevention. Adequate immobilization of the injured area is always of paramount importance.

*Myorrhaphy* or suturing of a muscle follows the same surgical principles as mentioned under the treatment of rupture of muscles. A *cicatrix* may form in an unsutured muscle wound which because of pain or disturbance of function may require excision and secondary suture. *Partial myectomy* is a procedure performed occasionally, for example, the excision of two thirds of the sternomastoid muscle for the relief of severe torticollis. *Myoplasty*, *muscle lengthening* and *transplantation* find an increasing usefulness in the correction of deformities and defects.

#### INFLAMMATIONS (ACUTE AND CHRONIC)

Acute myositis may be primary (traumatic) or secondary (infective). The former follows an open wound or subcutaneous injury of the muscle, and the latter is usually consecutive to a focus of infection near or distant. The myositis may be circumscribed or diffuse. Infective myositis, especially if of hematogenous origin, may be circumscribed and usually ends in suppuration. The local symptoms are related to the muscle or muscles affected and the general symptoms to the type and extent of the myositis. If infective, the symptoms depend on the virulence of the organism. If suppuration occurs, then adequate incision and drainage parallel to the muscular fiber

should be performed otherwise rest, heat and later physiotherapy are essential in the treatment.

*Fibrositis*, commonly known as *muscular rheumatism*, accounts for conditions referred to as lumbago, stiff neck, pleuritic pain, and so on. Pathologically, it is explained on the basis of an inflammatory hyperplasia of the connective tissue. The onset is sudden and the pain is severe and intensified by movements of the affected part. The muscles involved become swollen, spasmodic and tender to palpation and gradually contract. This condition often follows trauma such as a sprain or contusion or exposure to cold but frequently it proves to be a subfocus of infection in the tonsils, prostate or other sources. Removal of the primary focus, heat, deep massage and gradual stretching of the contracted muscles usually improve the condition. Attention should be directed to a bland diet, forcing of fluids and regulation of the bowels. At first it is often necessary to resort to salicylates or even morphine to relieve the pain. Daily exercises afterward will often prevent a recurrence.

*Chronic myositis* may be simple or specific. The simple may be fibrous or osseous. The *fibrous type* usually follows an acute myositis or is found around chronic inflammatory lesions (ulcers of the skin, osteomyelitic sinuses and so on). The muscles are indurated and grayish in color and their fibers are overwhelmed by the connective tissue proliferation.

The *osseous type*, *myositis ossificans*, may be partial and circumscribed (osteoma) or progressive and generalized. The former is the result of a single or repeated trauma. Its development is very rapid. It may be localized at first only in the muscle and aside from its induration give little inconvenience. The osteoma may become attached firmly to the underlying bone, thus greatly impairing the function of the limb and producing pain. The usual sites are the deltoid and the pectoral muscles in infants; in men, the brachialis following dislocation of the elbow, the adductor longus in horseback riders and the vastus lateralis following a kick. When the osteoma is painful or when it impairs function, it should be excised.

Progressive ossifying myositis is due to an infiltration of osseous substance into the connective system of the muscles tendons and aponeuroses. At first there is an embryonic infiltration of the connective tissue and then a fibrous induration which ends in ossification. This is a rare condition of unknown etiology (probably infective) which mostly affects males and which at first is limited usually to the muscles of the neck, back and thorax, later extending to the muscles of the limbs. The disease advances by exacerbations until all the striated muscles of the body are involved even those of the jaws and the unfortunate victim usually dies of an intercurrent disease. Because of the progressive nature of the condition treatment is unsatisfactory. At most a mass which interferes with function or is painful should be divided or should be entirely removed.

Chronic specific myositis includes tuberculosis, syphilis and actinomycosis of the muscle. Tuberculosis is rarely primary or hemogenous in origin, most often it is secondary, being due to direct extension from an adjacent tuberculous structure usually from a bone or joint. One may find an indurated mass in the belly of the muscle due to a dissemination of nodules or central caseation may occur and later large abscesses with discharging sinuses may form.

Syphilitic myositis usually occurs in the secondary and tertiary periods. In the early secondary stage there are dull nocturnal pains in the muscles of the neck and back; in the late secondary period contractures of the biceps and hamstrings occur which gradually interfere with full extension of the elbow and the knee. In the tertiary stage individual muscles are the seat of the interstitial or sclerosing type or of gummatous. These later on either undergo fibrous transformation or softening and ulceration. These affections yield readily to antisyphilitic treatment. For the contractures surgical treatment may be necessary.

Actinomycosis may involve muscles as well as other structures and when possible the entire affected area should be excised thoroughly. Iodids in large doses are often considered to be beneficial.

#### MUSCULAR CHANGES (ATROPHY, DEGENERATION, HYPERTROPHY, CONTRACTURE)

Atrophy of muscles arises from disuse, from overwork, from trauma, from prolonged pressure, from interference with the circulation or from central or peripheral lesions of motor nerves.

The muscles become smaller and flaccid. Their functional power decreases slowly or rapidly and atrophy may progress to the complete loss of contractile substance. The anatomic alterations vary and depend on the etiology. In atrophy due to nonuse the fibers though smaller in size are normal in structure and appearance. In atrophy resulting from interference with the nerve supply the fibrils degenerate into granules of fat which later on are absorbed and the whole muscle is transformed into fibrous connective bands which finally produce the deformed and permanent attitude of the parts.

Degeneration of muscles may be fatty, the result of atrophies due to central or peripheral lesions or may follow infectious diseases such as typhoid fever. Other forms are granular, calcareous and pigmented. Treatment consists of elimination of the etiologic factor producing the atrophy or degeneration followed by electrical stimulation and physiotherapy.

True hypertrophy of the muscles is the result of the increased use of the muscles and an increase of their fibers. In pseudo hypertrophy although the volume of the muscles is increased their strength is nil because the fibers have been replaced by fat or connective tissue.

Contracture of muscles occurs after most injuries if a group of muscles remains for some time in a state of flexion or following an inflammation in the muscle itself or lesions of its nerves. Heat, massage and gradual and prolonged stretching are usually beneficial, occasionally stretching and breaking up the adhesions under anæsthesia is necessary. Surgical intervention (muscle lengthening, etc.) may be indicated as a last resort.

Paralytic contractures, especially those following anterior poliomyelitis, should be prevented by keeping the limbs in the most favorable positions using artificial means.

if necessary, and physiotherapy to improve the muscle tone

**Volkman's contracture**, often spoken of as ischemic myositis and as ischemic muscular atrophy was first described by Volkman in 1872. While it is usually thought of as a sequel to injuries about the elbow resulting from interference with the blood supply from splints, casts or bandages too tightly applied it occurs elsewhere and also in the absence of constricting bandages sufficiently frequently to indicate that its common site in the forearm and the factors of constriction are to be considered only as associated factors. Ischemia of the affected muscles resulting in necrosis with later fibrosis of the muscle fibers produces an apparent shortening of the flexor tendons. The factors initiating the ischemia are not completely and clearly defined. According to Leriche, an arterial lesion such as occlusion by embolus or spasm produces muscular ischemia resulting in a limited area of necrosis. While venous stasis swelling and extravasation of blood especially beneath the lacertus fibrosus or brachial fascia may be considered as contributing factors they are not necessary for the initiation of this condition.

**Symptoms**—This syndrome usually has a rapid onset. Occasionally a few hours after the initiating injury one finds paralysis with the fingers held in flexion. The pain may be intense and should lead to an early diagnosis but unfortunately this may be absent and the condition is not recognized until late. Decrease in the circulation to the fingers and absence of the radial pulse are more valuable signs as they are likely to be noted earlier if watched for. Later one finds a marked wasting of the forearm and the muscles are indurated and tender. The interphalangeal joints are flexed strongly when the wrist is extended and may be straightened only by flexing the wrist. The hand is pronated and the forearm flexed. Trophic changes of the nails and ulcerations from pressure points may be found.

**Treatment**—The best treatment is of course prophylactic. This consists of being careful to assure an adequate circulation to the forearm and hand. Careful manipulation of the fracture and the application of properly fitting splints or bandages and their

early removal in the event of any evidence of interference with the circulation are important for often only a few hours is sufficient for the beginning of this syndrome. Leriche emphasizes the necessity for early intervention. If there is evidence of a decrease in the volume of the arterial pulse at the wrist as measured by an oscillogometer the brachial artery and its bifurcation should be exposed. Griffiths and Foie agree with the concept that the initiating factor is a decrease in arterial blood supply to the muscle. Treatment is therefore directed toward restoration of the circulation through the artery and its collaterals by means of resection of the injured torn or spastic artery, periarterial sympathectomy, cervical sympathetic block or injections of acetylcholine. After the condition is well established treatment is not very satisfactory. This consists of an attempt to restore function by means of physiotherapy or by means of corrective operations.

#### NEOPLASMS

The majority of tumors grow from the connective tissue of the muscle. They may be primary or secondary, benign or malignant. Primary benign tumors (fibroma, lipoma, angioma, etc.) are rare and usually benign. Primary malignant tumors (sarcoma) also are found. Secondary tumors are the sarcoma and the carcinoma and originate by metastasis or from propagation from neighboring structures. A tumor of this type forms a localized swelling under the fascia in the muscle which becomes fixed and firm when the muscle contracts and soft and movable laterally when it relaxes.

Benign tumors which produce symptoms should be excised otherwise they will enlarge and cause atrophy of the muscular fibers. When the tumor is malignant then the entire muscle or group of muscles with adjacent tissue should be removed and examined microscopically. Frequently amputation of a limb is found to be necessary.

#### PARASITES

Three parasitic diseases of muscles are encountered. 1. Cysticercosis is a rare disease now that meats are subject to sanitary inspection and the treatment of tapeworm is so improved. The cystic nodules may be



the size of a pea or cherry and occasionally of a hazelnut. The affected muscles become weak and painful.

2 **Trichiniasis** or **trichinosis**, is produced by the *Trichina spiralis* contained in infected meats usually pork which has not been thoroughly cooked. The parasites become encapsulated in the muscles and may or may not produce local symptoms of muscular pain, swelling and tenderness. The functional disturbance is in relation to the muscles involved. In cases of cysticercosis and trichinosis the nodules should be excised and constitutional treatment instituted.

3 **Hydatid cysts** are caused by the *Taenia echinococcus* the sites of election being the liver and lungs rarely the muscles. When they are found in muscles treatment consists in excision of the entire cyst, great care being taken to avoid leakage of the contents and consequent dissemination of the disease.

## SURGERY OF THE LIGAMENTS

### CONGENITAL DEFORMITIES

Since a portion of the human body may be congenitally absent one cannot doubt that this applies also to ligaments. In order to determine the congenital absence of ligaments it will first be necessary to decide what is to be meant by that term. One now speaks of true and false ligaments but there is no agreement regarding the matter. Even if one excluded such highly variable structures as the so-called transverse humeral and scapular and the glenohumeral ligaments it would still be true that there would be great variability. This applies especially to ligaments which are merely thickenings of the deep fascia such as the volar and dorsal carpal and the transverse and cruciate crural ligaments and the inguinal ligament. There also is great variation in ligaments associated with some of the great joints such as the hip joint even if one excludes the retinacula of the femur. Moreover it is not uncommon for the round ligament of the head of the femur to be absent though it is doubtful whether it ever is congenitally absent except perhaps when the entire femur is not present.

As the structure of ligaments is so similar to that of tendons the operations on them follow the same general principles and therefore will be considered only briefly in this chapter.

### TRAUMATIC LESIONS

**Sprains**—By a *sprain* is meant the aggregate of the various lesions which are produced in and about a joint whenever its movements are carried beyond the normal range or in some direction in which the range is very limited. Muscles play an important role in supporting joints and therefore if sudden violence occurs when the muscles are relaxed or at a disadvantage a sprain is produced if the force is sufficient a sprain fracture or even a dislocation may occur. Joints with an extensive range of motion such as the shoulder or the hip are less subject to sprains but more prone to dislocation.

The causes of sprains are direct and indirect depending on how near the joint the trauma acts. Predisposing factors are previous sprains, certain deformities (such as pes planus or genu valgum), muscular atrophy and acquired or congenital relaxation of the ligaments. In order of frequency sprains occur in the ankle, knee, wrist, elbow and spine.

The lesions of a sprain may involve many of the structures surrounding the joint, and the extent of the damage depends on the intensity of the trauma. A ligament which is stretched suddenly may tear, it may rupture at its point of attachment or it may even avulse a piece of bone of varying size (sprain fracture). Intra-articular cartilages may be displaced or torn as in the knee. Periarthritic lesions also occur such as overstretching and tearing of muscles or tearing or displacement of tendons and ecchymosis of the subcutaneous tissue. The synovial membranes may be torn with formation of a hemarthrosis. Very important is the muscular atrophy which follows a severe sprain with synovitis and effusion (such as is seen in lesions of the knee with consecutive reflex atrophy of the quadriceps muscle which greatly prolongs the disability). In a sprain the lesion may extend from the joint primarily affected to nearby and distant joints as often occurs in cases of sprained ankle in

which the joints of the foot are often involved

*Symptoms* are pain swelling ecchymosis limitation or impossibility of movements of the joint At first the pain is sharp and severe and later becomes a dull deep ache Palpation elicits tenderness along the joint line or over the insertions of the torn ligaments There is also cutaneous tenderness caused by the sprain of the underlying muscles

The *diagnosis* of an uncomplicated sprain can be reached only after the elimination of laceration of important ligaments luxation epiphyseal separation and articular fractures In rupture of important ligaments there is abnormal mobility such as lateral movement in the elbow or knee In luxation the articular cavity is empty the displaced bone is in an abnormal position and there is an impairment of the function of the limb Since many sprains are often complicated by fractures it is always wise to have roentgenograms taken (In sprains in the young there may be fractures of the cartilages which the roentgenograms do not reveal and can be diagnosed only by palpation hence the x ray should supplement and not be substituted for one's tactile sensation)

*Prognosis*—Gradually the blood and synovium are absorbed and the lacerated ligaments reunited As healing occurs adhesions often form in the joint or in the surrounding tendon sheaths If an uncomplicated sprain is treated early and effectively recovery is obtained in a few weeks

*Treatment*—Early care is important Limiting the motion of the joint by adhesive or elastic bandage will do much to prevent effusion into the joint If marked effusion does occur aspiration may be indicated Elevation of the joint tends to lessen the swelling and pain as does an evenly applied and snugly fitting dressing Heat effleurage and later massage help to accelerate absorption and restore function Early movement should be encouraged especially in sprain of the ankle unless there is evidence of gross tearing of the ligaments Decided encouragement for early function is afforded by the injection of novocain as suggested by Leriche directly into the areas where tenderness is elicited The patient is al-

lowed to walk about and if pain recurs the injection may be repeated Active use of the ankle tends to decrease the swelling and stiffness about the injured part and promote early healing

*Syndesmotomy*—Ligaments may be severed in accidental wounds or as an incident in operations on the joints or spine In either event the repair should be executed accurately with strong but not too heavy chromic catgut kangaroo tendon or fascial strips

Shortening or lengthening of ligaments may be necessary occasionally in order to correct deformities due to disease

*Rupture of Crucial Ligaments*—One should consider the probability of rupture of the anterior crucial ligament after a severe sprain of the knee whenever there is hemarthrosis, hyperextension is possible with the knee completely extended there is internal rotation of the leg at the knee if the head of the tibia can be slipped forward on the femur or if there is a lateral mobility that is a lateral abduction (lateral rocking) with the knee in the semiflexed position Usually associated with this lesion is damage to the internal lateral ligament and even displacement of the internal semilunar cartilage Rupture of the posterior crucial ligament is to be considered if when the leg is fully flexed the head of the tibia can be slipped back on the femur

If the tibial spine has been avulsed and a chip of bone torn from the femoral condyle this will be seen readily in the roentgenograms

Considerable pain will be present as a result of distention of the joint capsule with blood Immediate aspiration under the most aseptic conditions will afford great relief If only the crucial is torn complete immobilization in a cast over a long period will suffice If there has been rupture of the internal lateral ligament also only arthrotomy and repair will effect a cure This is best accomplished through a long midline incision which curves to the inner border of the patella

EDGAR LOBBINGTON GILCHRIST

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## IX. THE BURSAE

### DISEASES OF AND INJURIES TO BURSAE

Bursae exist in large numbers in the body usually as cavities lined with serous or endothelial cells which secrete fluid and permit the ligaments muscles skin and other structures to move freely and with a minimum of irritation They vary in situation size and structure they may be adventitious and may develop from occupation or other forms of irritation such as that resulting from deformity of the spine with *kyphosis* as in tuberculosis or from the constant rubbing and pressure of tight shoes on the head of the first metatarsal bone Any bony prominence subjected to constant and forceful movement is capable of forming such a protective space Bursae may enlarge as do the more or less constant bursae and become filled with serous fluid blood or loose bodies or become infected and contain pus As many of these bursae lie in proximity to joints and attachment of muscles it is common to find that they are contiguous with and at times really an outpouching of the synovial membrane As a rule the deep bursa is the more constant its size varies somewhat with the patient's occupation and activities and it is subject to the same diseases as the joint with which it is connected When bursae become distended they are called bursal cysts or *hygromas* The superficial bursae are the most commonly affected and knowledge of their situation is often most useful in distinguishing bursitis from intra articular disease such as *synovitis* and *septic arthritis* In one instance an infected prepatellar bursa resulted in infection of the knee joint when the physician under the impression that he was dealing with a distended and infected knee forced an aspirating needle through the infected bursa and into the knee joint Unjustifiable economic loss and prolonged disability with pain result from failure to recognize the inflammatory lesions affecting deep bursae The physician must be

constantly on the lookout for these diseases and injuries remembering the anatomic and physiologic relation of the bursae to the patient's occupation and the fact that bursae are subject to trauma inflammation rheumatism gonorrhea syphilis tuberculosis neoplasms and gout

Bursitis may be classified as acute or chronic traumatic or infectious and syphilitic gouty or malignant

### **PATHOLOGY**

The reactions of bursae are similar to those of the synovial membranes There is first an increase in the formation of fluid and distention of the fibrous sac Later the bursal wall becomes edematous degenerated and thickened If the irritation causing the reaction continues symptoms of pressure will occur as the surrounding tissues are compressed motion of joints may be inhibited because of pain Traumatic bursitis may become infected bursitis and result in a local rise in temperature and edema of the extremity As the bursitis continues the lining membrane may form villi or adhesions may form multiple cysts Pedunculated masses with enlarged tips may hang into the sac in which case movement may cause a grating sound The masses sometimes break off and result in loose bodies and at times form cartilage If the bursa is in the region of a joint adhesions result in its partial obliteration and limitation of motion This is commonly seen in cases of subacromial bursitis Calcified masses often appear to exist in bursae but at operation they are found more often in the surrounding tendons or capsule In cases of long standing the wall may be many times the normal thickness and as a result of prolonged irritation and degeneration a fibrous fatty or even calcified *hygroma* may follow Infected bursae distend with pus and either penetrate the soft tissues to come to the surface or rupture Tuberculous bursae are as seen in the greater trochanter often secondary to involvement of bone and may

contain many rice bodies although the presence of the latter is not pathognomonic. Syphilitic bursae usually form during the tertiary stage and are prone to cause the formation of sinuses. Neoplasms of bursae are factors the surgeon takes into consideration. Chondromas and fibrosarcomas are the most frequent and the prepatellar bursa is the one usually involved.

### TREATMENT

The type of bursitis whether it is traumatic infectious septic tuberculous or syphilitic its chronicity and its situation are factors the surgeon takes into consideration in determining the course to be followed.

**Traumatic Bursitis**—In ordinary cases caused by trauma relief usually follows rest of the parts affected thus housemaid's knee responds when diagnosed early to avoidance of the kneeling position. When the irritation of the bursa is kept up as is often the case among scrubwomen and nurses the bursa assumes a cystic appearance from distention with fluid and a hygroma forms which resists conservative treatment and may fail to disappear. Rupture of these traumatic sacs is often sufficient to effect a cure. When the bursa is superficial this may be accomplished by firm pressure of the thumb. Aspiration of fluid and application of a firm bandage are often successful. Aspiration followed by repeated injection of an antiseptic solution such as metaphen or half strength tincture of iodine which causes irritation and stimulates or destroys the lining is common practice. As the bursae are at points of pressure and act as bearings traumatic bursitis should if the patient cooperates properly respond to rest or aspiration if not and should the bursa become chronically enlarged excision is justifiable and insures cure. The injection of saline or of procaine solution into a traumatic bursa which has resulted in a stiff and painful joint may give instant relief. A large distended hemorrhagic hygroma is best excised.

**Infectious Bursitis**—Infectious bursitis is often multiple and should be treated by removal of the primary source of infection. The teeth tonsils and other common sources of infection must be eliminated the parts involved must be put at rest and heat must

be used. Should the inflammation continue to cause enlargement of the bursa aspiration may be useful. The value of removal of foci of infection in multiple bursitis is illustrated in the following case.

*Case 1* A man about twenty years of age complained of enlarged and painful swellings at the shoulders and knees. Examination disclosed the subdeltoid and suprapatellar bursae to be distended with fluid. A diagnosis of infectious bursitis was made as the movements of the joints were free and the joints themselves were not distended. Following removal of infected teeth and tonsils and the use of physiotherapy complete relief was obtained and the swellings subsided.

Infected bursae (septic bursitis) require drainage this should be done early to prevent the lesion from becoming chronic and causing secondary involvement such as septic arthritis or edema and to avoid unnecessary loss of time in recovery. Should the drainage continue over a long period the bursa may be safely excised and the wound drained for a short time. In bacterial infections caused by streptococci staphylococci gonococci and pneumococci the use of sulfanilamide or sulfapyridine may be of value. Penicillin is proving useful in the treatment of some bacterial infections.

**Tuberculosis of the bursae** is often secondary to an underlying focus in the bone. Careful search for a primary source such as pulmonary tuberculosis is imperative and treatment should be directed along general antituberculous lines as well as toward the elimination of the affected bursa and the underlying focus in the bone. Drainage and aspiration are of little use. The treatment of choice is excision followed by the use of heliotherapy cod liver oil and other remedies to build up the patient's resistance.

**Syphilis of bursae** is rare and occurs in the tertiary stage it tends to chronicity and the formation of sinuses. The use of diagnostic laboratory tests and adequate anti-syphilitic treatment are advisable before resorting to surgical operation.

**Gouty bursitis** is characterized by chronic inflammatory changes and chalky deposits in the tissues pain and remissions from symptoms. In the writer's experience the adventitious bursae of the great toe and the olecranon are most frequently affected.

Under treatment by heat, diet and, in rare instances, excision, pain and swelling are relieved.

### PROGNOSIS

When a diagnosis of bursitis is made early and the etiological factor has been ascertained as being traumatic, the prognosis is usually good. If there is evidence of hemorrhage into the sac and aspiration or drainage is done early, the prognosis is likewise favorable. Rest of the extremity is important in obtaining prompt recovery; if the bursa is irritated by constant movement, the inflammation is continued, and further distention of the sac results. The longer irritation continues, the more difficult and

this may require considerable dissection. As a rule, aspiration in the early cases and excision in the more chronic cases, in which the bursa has become infected, are the best methods of treatment. A virulently infected bursa, however, should be drained; if the discharge continues, it can be excised later with safety.

### BURSAE OF THE SHOULDER

Bursae of the shoulder (Fig. 65) are of considerable interest; of these, the subdeltoid, or subacromial, bursa is the one most commonly affected. It is a large, constant bursa which lies beneath the deltoid muscle and over the capsule of the shoulder joint

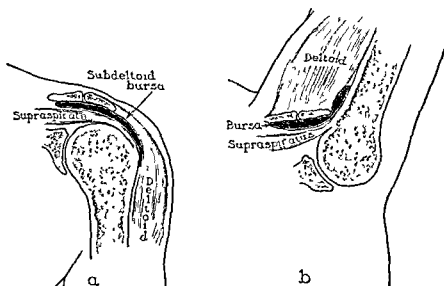


Fig. 65—*a*, Relation of subdeltoid bursa to supraspinatus muscle. *b*, Situation of the bursa during abduction of the humerus.

prolonged the recovery. The physician should therefore obtain the cooperation of the patient, especially in cases in which deep-lying bursae are likely to cause prolonged disability, because, when the bursitis has existed for some time, rest will necessarily result in greater economic loss than is usually required to obtain relief. A patient who has not cooperated properly or whose condition has been incorrectly diagnosed is the one who finally comes for relief when surgical operation is the only alternative. Then, aspiration is often repeated, only to have the bursa promptly refill. Incision and drainage may then result in prolonged and irritating discharge. Thus, the patient faces the necessity of having the bursa excised, and

and may connect with the bursa of the coracobrachialis muscle. Subdeltoid, or subacromial, bursitis causes pain, localized tenderness and limitation of movement of the shoulder joint. It is often confused with periarticular arthritis and rupture of the supraspinatus tendon. The calcareous deposits which are seen in roentgenograms are usually found to lie beneath the bursal sac, in the ligament. When the bursitis does not respond to conservative treatment, resort may be had to manipulation, with the patient under anesthesia, or to excision. The loose bodies and the calcareous deposits may be excised; the latter, however, are often absorbed under the influence of local use of heat and massage. Inflammation of

the subdeltoid bursa is not easy to diagnose correctly because the other anatomic structures about the joint are also affected by trauma and arthritis. Codman has done a monumental work on the subject and the student is referred to his book on the shoulder. The subscapularis bursa between the subscapularis muscle and the capsule is con-

sized needle. The method has also been employed successfully by Patterson and Darrach—Ed.]

*Case 2* A housewife aged forty-eight, complained of swelling of the right shoulder (Fig. 66) and of pain in the thorax of ten years' duration. Two years before admission stiffness of the shoulder with pain on motion of gradual onset had appeared without recogniz-

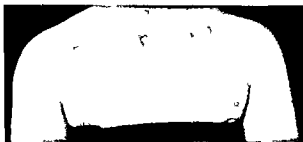


Fig. 66.—Bulging of the right subdeltoid bursa

ected with the joint. Other bursae to be considered about the shoulder are the subcutaneous acromial bursa and the bursa of the infraspinatus latissimus dorsi pectoralis major and the long head of the biceps brachii muscles. In the treatment of abnormal conditions of these bursae the position of abduction and external rotation pre-

able injury. A year later after severe exertion sharp excruciating pain had developed also a swelling had appeared which had increased in size. The pain in the thorax had seemed to bear a relation to the swelling in the shoulder; it had become worse when the patient noticed more swelling following exertion. She also complained of urinary frequency, tenesmus and nocturia and remembered that she had passed blood when twenty-five years of age.

On examination the patient was found to be of more than her usual weight; the pulse rate was 64 and temperature 98.2° F. The systolic blood pressure was 80 mm. of mercury, and the diastolic 64. Some rales were heard over the right side of the thorax. A large, soft tumor was present anteriorly over the right shoulder and had the feeling of containing rice bodies. The supraclavicular lymph nodes were palpable and hard. Urinalysis repeatedly revealed traces of albumin, occasional erythrocytes and occasional pus cells. Roentgenograms of the right shoulder were negative as were those of the thorax, stomach, kidneys, ureters and bladder. Roentgenologic examination of the spinal column gave evidence of spondylitis. Urologic examination including injection of guinea pigs with material from both kidneys was negative. The Wassermann reaction of the blood was negative and results of the blood count were within normal limits. The bursa was aspirated and a cloudy, milky fluid was obtained. The patient made a gradual recovery.



Fig. 67.—Large calcified subdeltoid bursa

vents shortening of muscles, stiffness in abduction, adhesions and the necessity of subsequent manipulation.

[An important contribution to the treatment of acute subdeltoid bursitis is the needling method of Alanson Weeks. Under local or general anesthesia the firm-walled sac is punctured in numerous places with a fair-

*Case 3* A school teacher aged forty-two complained of severe, almost unbearable pain in the right shoulder. The onset had been gradual and pain and partial disability had continued; pain had been noticed later in the fingers and toes. Her father had been afflicted with rheumatism.

On examination there was definite atrophy of the musculature of the shoulder, local tenderness over the bursa and limited abduction and rotation, especially internally of the shoulder joint. Urinalysis, blood count and Wassermann reaction of the blood were negative.

Evidence of paracapsular infection of the teeth was found. The tonsils had been cleanly removed. Roentgenograms of the right shoulder disclosed calcified masses; those of the thorax, wrists and fingers were negative. Opera-

ercises were commenced and foci of infection were removed. The patient improved rapidly and was released to continue treatment at home. She made an excellent recovery.

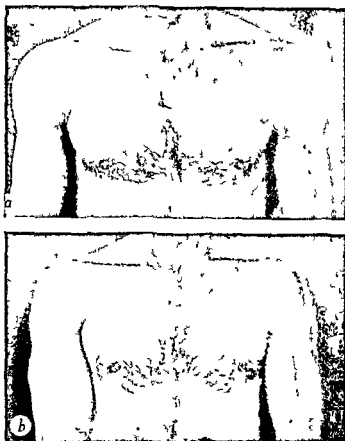


Fig. 68.—Bilateral subacromial tuberculous bursitis. *a*, before operation; *b*, three and a half years after operation.



Fig. 69.—Specimen showing rice bodies removed from right shoulder at operation in case 6.

tion was performed and the masses were found beneath the bursa and excised. They consisted of cheesy, white material which the pathologist reported to be inflammatory tissue containing calcium. Massage and

*Case 4.* The right breast of a woman aged forty-five was removed for chronic cystic mastitis. While in the hospital she complained of soreness in the left shoulder, which had troubled her for several months.



as well as of limitation of motion. At operation a calcified mass was removed from just beneath the bursa (Fig 65), this was  $\frac{1}{2}$  inch (1.27 cm) in diameter and  $\frac{1}{4}$  inch (0.6 cm) thick. The pathologist reported that the specimen consisted of cartilage and calcium. Convalescence was uneventful.

**Case 5** A woman aged fifty-six complained of pain and tenderness in the right shoulder, with limited motion in abduction. A calcified subdeltoid bursa was found. Treatment consisted of baking and massage, with graduated exercises. The patient was principally concerned about a toxic goiter and partial thyroidectomy was performed. While under treatment, the pain in the shoulder was relieved and she was dismissed to continue conservative treatment at home. The calcified masses may entirely disappear under treatment with such physiotherapeutic measures as heat, diathermy, massage and exercises.

**Case 6** A laborer aged thirty-seven years registered at the Mayo Clinic on Feb. 4, 1935. He stated that he had first noticed enlargement of the right shoulder about six years previously, and about a year and a half later the left shoulder had begun to show evidence of involvement. His trouble gradually increased until he was unable to abduct the arms fully, but he had continued his work up to the time of his admission.

Examination showed a semifluctuant bursal hygroma which crepitated (Fig 68). At operation on February 7, the subacromial bursae were excised and found to contain numerous rice bodies (Fig 69). The left bursa was much larger, as were the rice bodies contained therein. The result was excellent and when the patient was seen three and a half years subsequently, there was no sign of recurrence.

### OLECRANON BURSAE

At the elbow the olecranon bursa is commonly affected. The condition is called miner's elbow because of the constant pressure and trauma entailed in this occupation. The swelling beneath the skin and the olecranon process is, as a rule, painless unless infected. It responds readily to treatment. The so-called tennis elbow, radiohumeral bursitis, epicondylitis and epicondylalgia afflict those who follow some occupation which requires the use of a hammer or athletes who play such games as tennis. Pain in the elbow; tenderness over the radiohumeral joint, which is aggravated by continued effort; pain on lifting and closing the clenched fist and flexing the wrist; dropping of objects held in the hand, and weakness of the forearm are the common symptoms. Roentgenograms are negative. The essential pathologic change is inflammation under the conjoined tendon, and a bursa is found which may be removed if rest does not relieve the condition. Bursae may form about

the epicondyle and in the triceps brachii as well as in front of this muscle, but they are not commonly involved.

**Case 7** A salesman had fallen on his elbow four years before he came to the clinic. Two years after the accident the bursa had enlarged and then had disappeared. The enlargement had recurred later without evident cause. The bursa was excised and the patient had no further difficulty.

**Case 8** A farmer, aged thirty-four, had sustained injuries to the tip of the elbow two weeks previous to admission, with resulting swelling and moderate pain which had persisted. The roentgenograms were negative. The condition gradually subsided with conservative treatment.

An injured bursa, such as the one reported in case 8, as a rule, does not cause much complaint unless it becomes large or infected, after which it causes considerable trouble because of the bruising of the bony prominence and irritation of the ulnar nerve. When a bursa fails to subside under strapping and rest and continues to cause symptoms, excision is usually best.

### BURSAE ABOUT THE HIP

Bursae about the hip are numerous; Spalteholz has described sixteen bursae, and other authors have reported additional ones. The important ones are the iliopsoas bursa, between the common tendon of the psoas major and iliacus muscles and the joint with which it may connect; the subtendinous, between the common tendon of the psoas major and iliacus muscles and the lesser trochanter, the ischiogluteal, between the tuberosity of the ischium and the gluteus maximus muscle, and the bursa over the greater trochanter and the gluteus maximus muscle. The principal diagnostic aid in distinguishing bursitis from disease of the hip joint is the fact that in bursitis the motion of the joint is not restricted, or is restricted only in one direction, whereas in disease of the joint the motion is painful, restricted in all directions and accompanied by muscular spasm. As the iliopsoas bursa may connect with the hip joint, it is obvious that infection affects both, and the position of comfort would be in flexion of the hip. In tuberculosis the cold abscess may present anteriorly, because of the position of the bursa. If only the bursa is affected, the position of internal rotation or extreme ab-

duction will produce pain. Swelling of the extremity may occur in iliopectineal bursitis with infection, and the bursa may be mistaken for hernia. It is common for the bursa about the greater trochanter to be affected in tuberculosis. This is particularly common when the bone itself is involved. I have reported a series of nineteen such cases, and in 73 per cent evidence of tuberculosis was found in other parts of the body.

*Case 9* A farmer's wife had fallen downstairs and injured her right hip about five months before she came to the clinic. There had been ecchymosis and swelling over the greater trochanter and pain down under the outer side of the thigh. She had not been able to sleep on her right side and had felt better when at rest, although she had been able to walk. Three months after the accident, when she was rubbing

find that they are unable to sleep on the side affected. The pain usually extends down the outer side of the thigh. The patients are incapacitated by the pain but have free motion of the hip.

#### BURSAE ABOUT THE KNEE

The common bursa involved about the knee is the prepatellar bursa, situated between the skin and the patella. When it is subjected to trauma or infection, the condition is known as housemaid's knee. It is seldom painful, and it responds readily to treatment if the patient avoids further injury, otherwise, aspiration or excision is indicated. The deep infrapatellar bursa lies between the tuberosity of the tibia and the



Fig 70—Bilateral prepatellar bursitis in a farmer, aged forty years

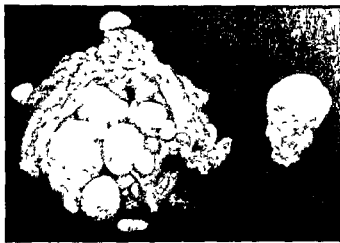


Fig 71.—At the left: Multiple loose bodies in an anserine bursa, about 5 cm in transverse diameter, which was removed unopened from the region in front of the left knee joint. At the right: Large osteocartilaginous body resulting from osteochondritis dissecans removed from the left knee joint, where it had caused symptoms of locking

the region of the hip because of continued soreness she had noticed a tumor; this had increased in size and had caused a great deal of discomfort.

On examination a tumor was palpable over the greater trochanter and along the posterior margin of the trochanter there was great tenderness. The motions of the hip were free. Urinalysis and the Wassermann reaction of the blood were negative. Results of the blood count were within normal limits. Roentgenograms of the femur and thorax were also negative. The bursa was excised, at operation, there was found an enlarged and thickened cyst which contained two loose, fatty bodies. Convalescence was uneventful, on inquiry six months later, the patient reported that she was well.

In cases of inflammation of the bursa that lies over the greater trochanter, the patients

patellar ligament; when enlarged, it may present a swelling on either side of the patella. The suprapatellar bursa or pouch is, in my opinion, part of the knee joint. In the differential diagnosis of synovitis and bursitis, it is well to remember that in the former there is imparted to the palpating hand a ballottement or sensation of something floating when the patella is pushed against the femur; in the latter, the patella remains firmly against the bone. Popliteal bursae may result from outpouching of the synovial membrane of the knee joint, and when excision is attempted, the hernia will be found to come from the posterior cap-

sule (Figs 70 and 71) These and the bursae about the semimembranosus and gastrocnemius muscles are painful only when they cause pressure on the blood vessels and nerves The treatment is along the same lines as for other painful bursae unless a hernia of the synovial membrane is found, in which case an attempt should be made to close the opening by scarifying the capsule and suturing fibrous tissue over the

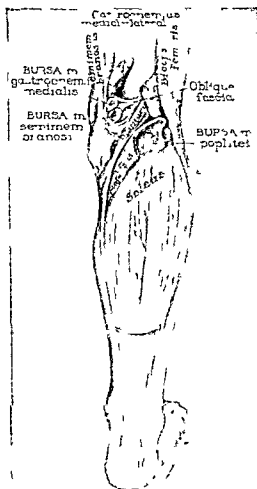


Fig 72—Location of bursae with relation to the muscles of the popliteal space

hole The patellar bursa which is not connected with the knee joint, is readily removed through a transverse incision with excellent results It is the common site of syphilitic bursitis and if a sinus persists, it is well to investigate for syphilitic infection Following excision a splint should be used to immobilize the knee for ten days

**Case 10** A farmer aged seventy-eight, complained of a growth on the knee which had been present for twenty five years Four days previous it had ruptured

and drained He could not remember any definite trauma nor had he suffered any marked pain or discomfort The action of the knee was unimpaired

Examination disclosed a huge cystic mass prepatellar in origin which completely surrounded and obscured the patella There was an area of recent hemorrhage at the point of drainage which had healed and closed The systolic blood pressure was 230 mm of mercury and the diastolic 115 The pulse rate and temperature were normal Urinalysis was negative The results of the blood count were within normal limits Roentgenograms were negative except for evidence of a mass of soft tissue about the patella and evidence of calcified arteries A diagnosis of essential hypertension arteriosclerosis and prepatellar hygroma was made Under local anesthesia the mass was excised The pathologist reported that the tissue was a degenerating mucinous hemorrhagic cyst

**Case 10** illustrates the fact that chronic bursitis may exist for many years without causing disability Figure 72 illustrates the appearance of the knee in a case which is not reported here

**Case 11** A salesman aged forty nine complained of persistent pain and swelling about the right knee following a fall about nine months previous to admission and a second fall six months later Following the first injury, the pain had ceased in a few days but the swelling had persisted After the second injury the pain had persisted and had been aggravated by walking the swelling had enlarged

General examination did not disclose any foci of infection The results of a blood count were within normal limits Urinalysis and the Wassermann reaction of the blood were negative At operation an enlarged infrapatellar bursa was found which was filled with red jelly like material Several small collections of similar material were excised along the inferior border of the capsule and as far as the anserine bursa which was enlarged and contained a white jelly like material which was also excised Further examination disclosed an enlarged prepatellar bursa undergoing degenerative changes this was also excised The discoloration in the infrapatellar bursa was caused by blood the thick glairy mucinous jelly like material which was found in the anserine bursa was similar to that usually found in these cystic cavities The patient had an uneventful convalescence The pathologist reported 'three bursae' (Fig 71)

## BURSAE OF THE FOOT

**Bunion.**—A bunion is an inflammation of the adventitious bursa over the head of the first metatarsal bone It may lead to formation of a sinus and extreme pain and may require excision The bony enlargement of the head of the first metatarsal bone may require removal, as hallux valgus is a common contributing factor Women's shoes especially the type with high heels are the

cause of such conditions in many instances, and proper footwear, with lower and broader heels as well as more roomy toe space, is essential for relief.

**Bursae of the heel** cause considerable discomfort, especially to women who wear poorly fitted shoes. These bursae become enlarged and painful, and are often infected. Removal of the cause of irritation is the best way of relieving the pain. The hard

inflammation has subsided. Later, the infected bursa may be removed or drained with safety. Because of modern footwear, the subcutaneous bursa which lies over the insertion of the tendo achillis is often involved, as is also an adventitious bursa over the head of the first metatarsal bone. The proximity of nerves in such regions makes the inflammation very painful, and recourse to pads and ointments is common; but the

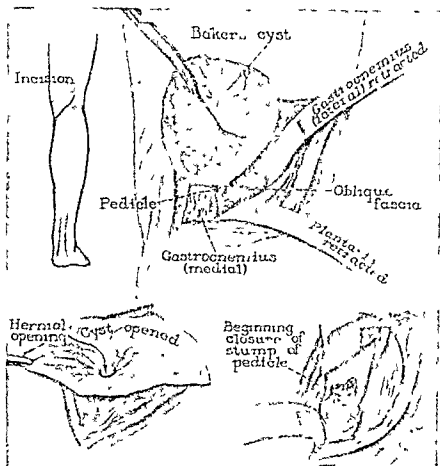


Fig 73—The surgical technique employed. The oblique incision is made over the popliteal space and along the course of the cyst, the cyst is dissected free and the pedicle exposed at the point of entrance into the joint, cyst opened to show inner surface and hermal opening into the joint, and pedicle exposed after excision of cyst.

counter of the shoes may be removed in cases of inflammation of the bursa of the tendo achillis. A patient should stay off her feet if possible, especially when there is evidence of infection. I never incise for an acute bursal infection, because I feel that the association of bursae and the lymphatic structures may result in septicemia. In such cases, boric acid and alcohol dressings should be applied; after which the patient should be advised to remain in bed until the in-

quickest way to give relief is to have the patient wear proper footwear and rest the feet.

**Case 12** A woman aged twenty-one, came for relief of painful heels. Three years previous to admission, without illness or injury, aching pains had developed in the backs of both heels. Pain had persisted in spite of wearing pads, and the greatest relief had come with rest and walking on the toes.

Examination showed a thickened callous, with fissures over the posterior aspects of both calcanei and local tenderness. Roentgenograms of the feet were

negative. The patient was provided with proper shoes and pads.

Some styles of shoes with very high heels have been reduced in bulk until they are slippers which are difficult to hold on the feet. In order to make them secure, the counter has been drawn in so that it frequently cuts into the tendo achillis in the region of the subcutaneous bursa, the resulting trauma produces a callosity and bursitis. These bursae and callosities disappear with the use of properly fitting shoes and temporary pads. The danger that the fissures may become infected is to be emphasized as this infection may lead to lymphangitis and septicemia with fatal termination.

A common form of bursitis in the foot is that which develops under the tuber calcanei and the fatty pad over the heel. The inflamed bursa becomes exquisitely tender and makes walking and standing difficult. This bursa is often affected in infectious diseases and the condition may fail to be relieved by rest, heat or pads worn in the shoes, it then becomes necessary to excise the bursa through a lateral incision.

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## X THE VASCULAR SYSTEM

### CONGENITAL ABNORMALITIES

According to the embryological studies of Sabin and Woodard arteries and veins develop from a common capillary plexus. At certain stages in this development vessels may serve interchangeably as carriers of arterial and venous blood before their final differentiation into arteries and veins. Moreover in embryonic life multitudinous direct communications between the arterial and venous systems have been observed without the interposition of a capillary bed. On rare occasions one or more of these direct connections may persist beyond uterine life.

Such abnormal communications are postulated as the primary factor in the development of hemangioma (nevus telangiectasis *mother's mark*) *cirsoid aneurysm* (plexiform angioma *racemose angioma*) and congenital arteriovenous fistula. To similar vagaries in the development of arteries and veins from a common capillary plexus is ascribed the occurrence of *port wine* or *claret* stains which are pink or bluish discolorations of the skin due to numerous dilated intradermal vessels.

**Angioma**—An angioma (Fig 74) composed largely of dilated blood vessels and endothelium lined blood spaces in a framework of fibrous tissue and fat may arise in any part of the body including skin subcutaneous tissue muscles long bones vertebrae skull liver brain or spinal cord. Although it is not strictly a tumor in the sense of a neoplastic growth the dilated and elongated blood vessels with their contained blood produce a space-occupying mass which provokes symptoms characteristic of its location and size. Situated in a vertebra it may produce paralysis and anasthesia comparable to that resulting from a tumor of the spinal cord.

In the newborn an angioma may be present as a subcutaneous or deeply seated swelling easily compressible sometimes pulsating and frequently appearing in the surface over a limited area as a mottled reddish or bluish mass over which the skin is

very thin. This swelling may spontaneously disappear presumably as a result of thrombosis of the abnormal communication or communications it may remain stationary or it may grow rapidly depending on the size of the vessels abnormally connected and on the size of the abnormal communication itself. It may develop into a cavernous angioma the large endothelium lined spaces of which may ulcerate producing serious or fatal hemorrhage. Occasionally the increased local heat the red discoloration and thinned out appearance of the skin overlying a hemangioma may suggest the diagnosis of an abscess a mortifying nodule. An accurate and chronologic history should prevent such an error.

"*Cirsoid aneurysm*" is properly only a descriptive term applied to a remarkable dilatation of vessels arteries as well as veins that occurs in the scalp in the brain and in the subcutaneous tissues of the extremities in connection with arteriovenous communications usually congenital in origin. However the frequent occurrence of a *cirsoid aneurysm* about the scalp and head and its rapid postnatal development have suggested that the trauma of birth may by contusions be responsible for the abnormal opening between the artery and its adjacent vein. *Cirsoid aneurysms* have been known to occur at the site of a hematoma caused during labor (Reid).

**Congenital Arteriovenous Communications**—The most frequent location of a congenital fistula is in the neck and in the extremities. Except in certain extremely unusual and remarkable instances the exact point of fistulous communication may be difficult to demonstrate as it may be impossible to say where the artery ends and the vein begins. Recorded in the literature are examples of such communications between the carotid and jugular vessels the subclavian vessel the tibial vessel the brachial vessel and the intracranial vessels. The ultimate effect of such abnormal communications is to transfer blood under ar

terial pressure directly into the venous bed, with resulting venous dilatation. When these communications are located in the extremity, engorgement and dilatation of superficial veins may be extreme and may be accompanied by ulceration of the skin. Operations for the relief of supposed varicose

the period of growth, particularly at the epiphyseal line, brought about by the increased vascularity of the extremity. The decreased resistance to the flow of blood from artery to vein at the site of the fistula as compared to the resistance to the flow of blood through the capillary bed elsewhere attracts a large volume of blood to the fistula, thereby causing an opening up and dilatation of all vessels approaching the fistula. The surface temperature of the extremity may be increased, particularly in the neighborhood of the fistula, which is also an expression of the increased vascularity of the part. Blood withdrawn from a surface vein may be found to contain a considerable admixture of oxygenated arterial blood (Brown). This fact provides an authoritative test for the presence of an arteriovenous fistula. As in experimental and traumatic fistulas the heart may be enlarged, and the main artery proximal to the opening may be dilated.

The characteristic thrill and bruit of a fistula may be absent, but when present they are most pronounced over the site of the fistula and are propagated both distally and proximally along the course of the involved vein. Pressure directly over the opening obliterates the thrill and bruit, but pressure over the vein at any point proximal to the opening controls the bruit also, a fact which may lead to a mistake in locating the exact site of the abnormal opening. The intracranial fistula produces a bruit which can be heard both subjectively and objectively.

**Treatment.**—The treatment of *hemangioma* consists in excision as promptly as possible after birth to avoid further growth and extension. In certain cases, because of size, the excision is performed in multiple stages. Where large areas of skin are involved grafting may be necessary. About the face and head it may be found desirable to apply electric coagulation to small areas at repeated sittings.

*A cirroid aneurysm* is cured by excising or eliminating by ligation the abnormal opening or openings. This may be exceedingly difficult and may necessitate the removal of large masses of dilated vessels in order to be sure to include the abnormal openings, the exact site of which may not always be ascertainable. When the communications lie in



Fig 74—Congenital hemangioma of the hand. Note the marked dilatation of the superficial vessels, the dilated radial artery, and the increased length of the right radius and ulna.

veins have been performed with almost disastrous results because of arterial bleeding from veins. The affected extremity may be larger in circumference and its bones longer than those of its normal fellow (Fig. 74). The increase in the length of bone is ascribed to the improved nutrition during

the bone as in the extremities amputation provides the only cure. A hemangioma of the body of the vertebra has been known to respond favorably to radiation therapy. The use of a sterilized stethoscope at operation may prevent failure to obliterate all abnormal openings. As long as a bruit is heard the heart of the trouble has not been eliminated. Loss of blood must be avoided since a fall in blood pressure will in itself abolish the thrill and bruit and thereby prevent the detection of the site of communication. Failure to control all abnormal openings will result in a recurrence of dilated vessels—a circumstance which has led writers to consider a cirroid aneurysm as neoplastic in origin.

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#### VASCULAR TISSUE TUMORS

Blood vessels are composed of an inner endothelial lining a fibroelastic supportive framework contractile tissue<sup>1</sup> which is smooth muscle in the larger vessels and pericytes<sup>1</sup> in the capillaries and a rich plexus of sympathetic nerves. Both benign and malignant tumors composed of these various elements are recognized. All are compounded of several tissues but each tumor type is characterized by some special feature from which its name is derived. They may develop at any age and wherever blood vessels are found but the great majority appear in the superficial tissues early in life and are often multiple. Most of them probably come from segregated vascular anlagen<sup>2</sup> which develop later than and separate from the vascular system although the tumor vessels usually contain circulating blood. The simplest tumor form is the *cavernous hemangioma*. If the capillaries are widely dilated into spaces the tumor is called *cavernous hemangioma*. If the component vessels have smooth muscle in their walls the term *venous hemangioma* is applied. Fat and extravascular smooth muscle

are sometimes associated. If the stromal smooth muscle predominates the growth is a *vascular leiomyoma*. Skin leiomyomas<sup>3</sup> may cause attacks of proximal pain. The vascular tumors characterized by a dominance of endothelial cells are called *hemangioendotheliomas*<sup>4</sup>. Most of these tumors are malignant but a rare benign form occurs in infants. The vascular tumors in which pericytes predominate are called *hemangiopericytomas*. The best known variety of these last is the *glomus tumor*<sup>5, 7</sup> so called because it is an hypertrophied caricature of the specialized arteriovenous anastomoses found in the hands and feet which are concerned with temperature control.<sup>8</sup> The glomus tumor may occur anywhere in the skin or beneath it but is commonest in the hands especially beneath the nail. In spite of its small size it frequently occasions proximal attacks of agonizing pain. Only excision will cure the pain. Other superficial tumors occasionally cause proximal pain<sup>9</sup> but it is commonest with glomus tumors and leiomyomas.

Rarely the *hemangiopericytoma* may display aggressive growth and metastasize<sup>10</sup> but the more familiar malignant tumor is the *hemangioendothelioma*. Although maintaining a basic tendency to form vascular tubes the malignant endothelial cells heap up within the lumens and sometimes dominate the whole field.<sup>4</sup> Metastases occur freely through the blood stream. The majority of the malignant hemangioendotheliomas are found in the liver spleen and superficial soft parts but they can arise in many other organs and tissues. The validity of the claim that malignant fibrous and smooth muscle tumors arise from the walls of large blood vessels is in question.<sup>10, 11</sup> Another possible example of malignant vascular tumor is furnished by Kaposi's disease<sup>1</sup> but it is questionable whether or not the disease is neoplastic.

The clinical aspect and treatment of these tumors vary so greatly that it would be confusing to attempt any dogmatic summary statements about them.<sup>12</sup> Almost all of them grow by infiltration at rates of speed extremely variable even for the same tumor at different times. All of the malignant tumors and many of the benign ones are best treated by excision but some benign ones are better dealt with by radiotherapy by



injections of sclerosing fluids or boiling water or by some combination of methods.

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### WOUNDS

Hemorrhage from a wounded artery may be external and easily controlled by digital pressure, or it may be concealed and rapidly fatal, as into the soft tissues of the thigh following fracture or into the capacious thorax following a puncture wound of the inaccessible innominate artery or into the abdomen following a stab wound of the iliac artery. Concealed hemorrhage should be suspected in a patient with a steadily rising pulse rate, an increasing respiratory rate, with air hunger, pallor, extreme restlessness, faintness and, finally, in rapid succession stupor, delirium, unconsciousness and death. Short longitudinal wounds of an artery are less dangerous than transverse wounds, and complete division of an artery may cause less bleeding than a tangential wound or partial division. When an artery is completely divided, the highly elastic quality of its wall causes it to retract into the tissues, thereby diminishing the caliber of the vessel and promoting clotting. Following incomplete division, the same elasticity causes the edges of the wound to gape even more widely, thus promoting bleeding.

The escape of blood into the soft tissues through an arterial wound may lead to the

development of a large pulsating hematoma which exhibits expansile pulsation and a to and fro bruit with a brief silent interval between the two phases. Beyond such an aneurysmal hematoma, pulsation in the arteries may be absent, the tissues may show a distinctly impaired circulation and gangrene may be imminent. If the wound in the artery is untreated the pulsating swelling may grow progressively larger, causing dis-



Fig 75.—Traumatic arteriovenous fistula between femoral vessels due to a gunshot wound. The circle marks the entrance site of the bullet. Note the increased size of the affected extremity, the dilated superficial veins and the varicose ulcer below the knee. The common femoral artery on the left was greatly dilated as compared with that on the right.

coloration, thinning and finally destruction of the overlying skin with perhaps fatal hemorrhage. Progressive growth of a swelling also increases the danger of gangrene of the extremity due to interference with the collateral circulation secondary to pressure of the aneurysmal mass. The localized pain and tenderness, the increased local heat, the redness and infiltration of overlying tissues may be mistakenly interpreted as being due to infection rather than to an aneurysmal

hematoma, a mistake attributed to many masters of the past, even to the doughty Pott and the testy Dupuytren.

When a wound of the artery involves the vein as well, a traumatic *arteriovenous fistula* is the result (Fig. 75). The temporary profuse bleeding may be easy to control, since the blood from the arterial wound is shunted directly into the vein. The extremity beyond the wound may swell to great size as a result of edema of the tissues incident to arterial pressure in the venous bed. Gangrene may develop, requiring amputation of the extremity, or the patient may

the circulation of the blood. It provides two routes through which the circulating blood may pass. Blood may flow through the normal channels as represented by the system of heart-artery-capillary bed and vein, or it may traverse a shorter circuit consisting of the heart-artery-fistula and vein (Fig. 76). Because of the fistula the peripheral resistance in the shorter circuit is considerably less than the resistance in the normal circuit.

Obviously the extent of the reduction in peripheral resistance and the amount of blood diverted through the fistula will depend on the size of the opening. A small

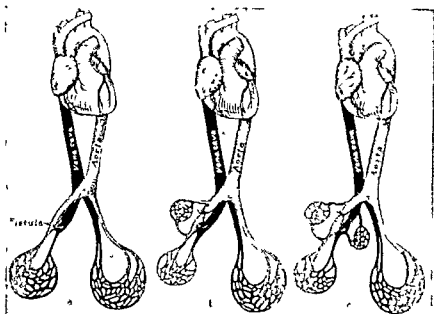


Fig. 76—*a*, Diagrammatic representation of the circulation in the presence of a femoral fistula, *b* ligation of the artery alone proximal to the fistula inevitably invites gangrene because of diversion of the collateral circulation through the fistula back to the heart, *c*, ligation of the artery and vein may prevent gangrene but does not cure the fistula.

die promptly from cerebral and myocardial anemia because of loss of blood and diversion of what little blood remained on the arterial side through the fistulous opening into the venous bed. The characteristic thrill and bruit are invariably present although sometimes delayed in appearance for days because of shock and low blood pressure. These are continuous through the cardiac cycle and not interrupted or biphasic as in a simple aneurysm. They are markedly accentuated during systole and are best felt and heard over the site of the fistula.

A fistula, if large, introduces profound disturbance in the physiologic laws governing

communication, not over 3 or 4 mm. in diameter, may exist between peripheral vessels for years, and aside from the mild local disturbance due to the continuous thrill and bruit, no other effects develop. The larger sized fistulas, from 5 to 15 mm. in diameter, divert so large a volume of blood from the general circulation that startling effects on the circulatory mechanism are produced. The immediate effect is a fall in general blood pressure and a marked acceleration in pulse rate. Within a few days a gradual readjustment begins which ultimately leads to complete recovery of the systolic blood pressure, and a gradual return to a normal pulse

rate. The primary factor in this recovery is an increase in the total blood volume an increase which has been shown experimentally to be commensurate with the size of the fistula.

If the fistula is large closure by digital compression by operation or by closure of the artery proximal to the fistula produces an abrupt rise in blood pressure and a fall in pulse rate (Fig 77). Reopening of the fistula causes a fall in blood pressure and a reacceleration in pulse rate. These phenomena when present are pathognomonic of an arteriovenous fistula as they do not occur

in a simple aneurysm. The increase in blood pressure and increased distention of the arterial bed—would lead to an excessively high blood pressure were it not for another compensatory mechanism. By overdistention of the arch of the aorta the depressor fibers of the vagus are stimulated the pulse rate drops the cardiac output is reduced and the excessive increase in blood pressure is prevented.

Another striking though not invariable feature of an arteriovenous fistula is the accompanying dilatation of the heart. This dilatation is progressive and may eventually result in cardiac decompensation and death.

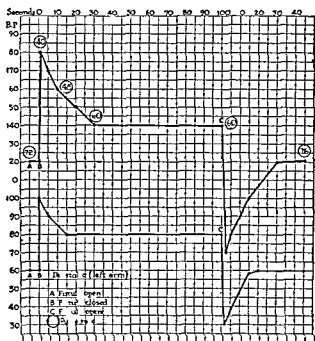


Fig 77—Chart illustrating the remarkable rise in blood pressure and fall in pulse rate when a femoral fistula is closed by digital compression and the fall in pressure and rise in pulse rate when the fistula is open features absolutely pathognomonic of an arteriovenous aneurysm as compared to a simple aneurysm.

in the presence of other aneurysmal dilatations.

The increase in general blood pressure when a fistula is closed depends on two factors normally intimately concerned with the maintenance of blood pressure: (a) the elimination of the fistula forces the circulating blood to pass through the normal capillary bed thus increasing peripheral resistance; (b) closure of the fistula forces the volume of blood formerly diverted through the fistula and for which compensation has occurred by an increase in total blood volume into the general arterial bed. The two circumstances—an increase in peripheral re-

sistance and an increased distention of the arterial bed—would lead to an excessively high blood pressure were it not for another compensatory mechanism. By overdistention of the arch of the aorta the depressor fibers of the vagus are stimulated the pulse rate drops the cardiac output is reduced and the excessive increase in blood pressure is prevented.

Another striking though not invariable feature of an arteriovenous fistula is the accompanying dilatation of the heart. This dilatation is progressive and may eventually result in cardiac decompensation and death.

*Treatment*—Temporary control of the hemorrhage in the period between injury and operation is effected by direct pressure on the bleeding point preferably with sterile gauze by digital pressure on the artery above the injury or by the application of a tourniquet when feasible. The latter should be avoided unless prompt operation can be undertaken since prolonged ischemia below a tourniquet favors (a) permanent nerve paralysis (b) gangrene due to interference with collateral circulation and (c) infection in tissues damaged by a lack of nutrition. *Ligation of vessels in the presence of infection* invites the danger of secondary hemorrhage due to destruction of the vessel wall and of the obliterating thrombus by microorganisms.

When feasible wounds of large arteries should be sutured promptly after their in-

jury under a tourniquet and the wound in the artery sutured or if this is impossible the artery should be ligated above and below the wound with complete division of the artery if it is not already so divided. If a tourniquet cannot be applied the artery above and below the laceration should be exposed through separate incisions if necessary and encircling tapes should be applied but not tied to be drawn tight for control of hemorrhage in case of need. By including in this temporary ligature a short segment of rubber tubing of the same diameter as the artery injury to the arterial wall is prevented and removal of the ligature is easily effected by cutting down on the tubing (Gordon Taylor).

In operating upon a pulsating hematoma or upon an arterial lesion with false sacs of the upper thigh where a tourniquet is not

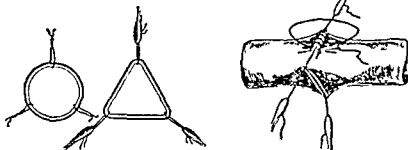


Fig. 8—A divided artery is most easily resutured according to Carrel's method of converting the circular orifice into a triangular one by the application of three traction sutures.

fection before inflammation has set in (Fig. 78). This depends on being able to control the hemorrhage from the wound by the application of a tourniquet above it or of small rubber shod clamps to the artery proximal and distal to the wound. Fine silk threaded on very fine needles and moistened in sterile white oil is the suture material used for arterial wounds. When available heparin should be administered for forty-eight hours after suture.

Occasionally in wounds involving tissues contiguous to a large artery the artery may be affected by a localized spasm sufficient to compromise the circulation beyond. Periarterial sympathectomy above and at the site of the spasm may be effective but if not interruption of the sympathetic trunk governing the vessel lumbar or thoracic is indicated.

A pulsating hematoma should be evacu-

applicable it is imperative to be able to control by temporary ligature both the common and the external iliac artery proximal to the lesion. These are best approached through an incision along the lateral border of the lower third of the rectus muscle, the arteries being exposed by reflection of the peritoneum. This incision also permits interruption of the lumbar sympathetics to improve the collateral circulation by peripheral vasodilatation (Gage).

Because of its progressive effects on the heart and circulation an arteriovenous fistula should be eliminated. If seen immediately after infliction the arterial and venous wounds may be sutured with restoration of the vessels. If the fistula is of recent origin delay in operating may be counselled (1) because small fistulas tend to heal spontaneously and (2) because delay favors the development of a collateral circulation and

diminishes the danger of gangrene if ligation of the vessels is found necessary. Whenever dilatation of the heart has occurred and alterations in pulse rate and blood pressure occur on digital closure of the fistula one may be certain that spontaneous closure is unlikely and that operation is necessary.

If it is a fistula of some duration the vessels may be separated and the wounds sutured or the rent in the artery may be sutured through an incision in the vein which is then ligated (Matras). Under no circumstances should the artery proximal to a fistula be ligated as for a simple aneurysm (Fig 76). Because of the absence of peripheral resistance at the fistula blood flowing through the collateral vessels would find its way through the fistula back to the heart instead of into the tissues distal to the fistula and gangrene would inevitably occur. The safest treatment consists in ligation of all vessels leading to and from the fistula followed by actual excision of the fistula.

Prolonged rest and a slow return to work are indicated after such excision. Considerable myocardial weakness may have developed during the prolonged period of dilatation and the cardiac muscle may prove temporarily inadequate against the increased peripheral resistance and the rise in diastolic pressure which follow the closure of a fistula.

**Pulsating Exophthalmos**—Fractures of the skull involving the sphenoid bone are occasionally accompanied by partial rupture of the carotid artery where it lies within the cavernous sinus. This is a variety of arteriovenous fistula which produces its own unique symptoms: a gradually protruding eyeball which finally becomes fixed, marked congestion and edema of the conjunctiva and numbness of the face and ptosis of greater or less degree. Subjectively such a lesion produces an intolerably noisy intracranial bruit from which the patient can never escape and which he feels will drive him insane if it cannot be controlled.

Immediate treatment consists of complete rest in bed, limitation of fluids and no straining or effort, not even at stool. Pressure over the common carotid artery, applied thrice daily, promotes closure by thrombosis at the site of communication.

Operative treatment consists in ligation of the internal carotid artery either through a transverse incision in the neck or intracranially as advocated by Dandy. The danger of hemiplegia due to cerebral ischemia prompts certain precautions. Simultaneous ligation of the jugular vein is considered mandatory by Watkins and others. Keegan first ligates the common carotid artery thus providing collateral circulation through the external carotid artery followed subsequently by ligation of the internal carotid artery if all symptoms do not disappear. These ligations may be performed with the patient under local anesthesia and the ligature may be removed if evidences of cerebral ischemia appear, i.e. somnolence, unconsciousness or hemiplegia, numbness and convulsions on the side of the body opposite the ligation.

**Ligation of Arteries**—In the ligation of large vessels the application of a ligature sufficiently tight to close the lumen invariably causes death of the tissue included in the ligature (Halsted). Healing occurs by envelopment of the ligature in fibroblasts and the substitution of fibrous tissue for the devitalized wall within the ligature. If a fine ligature is applied to a vessel in continuity the repeated trauma of expansile pulsation against a fixed point may result in rupture of the devitalized vessel wall at the point of ligation. A heavier ligature reduces the possibility of erosion of the vessel wall. Accordingly one may to advantage graduate the size of the ligature in proportion to the size of the vessel to be ligated (Reid). In ligating the abdominal aorta for example one would apply a tape ligature or a strip of fascia lata about  $\frac{1}{4}$  inch in width. The best protection against fatal erosion is ligation of the vessel at two points and division of the vessel between the ligatures. Following division retraction of the divided ends occurs and the force of each pulsation is no longer concentrated on a fixed point but is dissipated with each pulsation over a wider area through elongation and expansion of this thickened retracted end. Moreover ligation in continuity is frequently followed by re-establishment of the lumen nullifying the desired effects of such ligation.

In ligating large arteries one must always

consider also the necessity of maintaining a proper balance between the arterial and venous systems by simultaneously ligating the vein as well as the artery. Statistically, Sehrst and Heidreich have demonstrated the lessened incidence of gangrene following ligation of artery and vein as compared to the ligation of the artery alone a fact corroborated experimentally by Brooks. If division of the artery is followed by pulsation in the distal stump the vein need not be ligated since there is already an abundant collateral circulation (Pemberton). If the division of the artery is not followed by pulsation in the distal stump the vein also should be ligated in the hope of improving circulation beyond the divided artery by an increased resistance to the return flow to the heart of the collateral circulation.

Before the ligation of major peripheral arteries blocking the lumbar sympathetics in the case of the lower extremity and the cervicodorsal sympathetics in the case of the upper extremity has been advocated as a means of increasing the collateral circulation. The vasodilatation that accompanies such blocking may be sufficient to prevent gangrene. The blocking is effected by the injection of novocain followed by 3 to 5 cc. of 95 per cent alcohol (Gage and Ochsner).

With reference to the carotid vessels one may ligate the internal carotid or common carotid in children and young adults with impunity but in old adults ligation of the carotid should invariably be accompanied by ligation of the jugular vein also.

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## OCCLUSIVE DISEASES OF THE PERIPHERAL VESSELS

### I RAYNAUD'S DISEASE

(See section on Raynaud's Disease)

### II THROMBOANGITIS OBLITERANS

(*Endarteritis Obliterans* of Winiwarter (1870) *Presenile Juvenile or Spontaneous Gangrene* *Buerger's Disease*)

Thromboangitis obliterans is an occlusive disease of both arteries and veins occurring most conspicuously in either upper or lower extremities where it may be responsible for the maddening pain of ischemia, stubborn infections or gangrene. The same occlusive process has been described as occurring in the vessels of the brain, the heart, the kidney and the intestines. Although slowly and insidiously progressive and usually culminating in gangrene or death it is characterized by remarkable chronicity with prolonged remissions and occasional apparently permanent recoveries. Its frequent occurrence in young male adults given to excessive smoking and its extreme rarity in females early suggested tobacco as an etiologic agent. Additional evidence, however, absolves tobacco as the primary cause of the disease but as an excitant of the sympathetic nervous system tobacco may cause contraction of blood vessels already partially occluded and thereby aggravate the deleterious effects of such partial occlusion (Coller). Smoking by patients with thromboangitis generally results in decreased peripheral cutaneous temperatures, an increased pulse rate, an elevated blood pressure and a decreased oxygen saturation of the arterial blood (Theis-Freeland). Originally thought to be limited to the Jewish race, thromboangitis has since been de-

scribed in Gentiles Orientals and Turks. Although tobacco the ingestion of ergot and some obscure infectious agent have been invoked as probable causes of the disease no definite etiologic agent is known at present. Epidermophytosis is said to have an etiologic significance (Thompson).

Pathologically both the large and small vessels of a limb—veins as well as arteries—may show various stages of cellular thickening and proliferation of the intima associated ultimately with thrombosis limited to certain portions of the vascular tree.



Fig. 79.—Injection of the arterial tree in an amputated extremity in a case of thromboangiitis obliterans illustrating the remarkable development of collateral vessels. Compare with Fig. 81 (Reichert).

Subsequently this clot becomes organized, new vessels permeate the occluding mass of fibrous tissue and the lumen is partially restored. In the lower extremity the obliterative process may extend as high as the popliteal and femoral vessels but unlike arteriosclerosis it does not extend uniformly throughout the peripheral vascular bed. In the larger vessels occlusion alternates with patency and one may find in a given vessel all stages of thrombosis from a fresh soft clot to a completely organized recanalized thrombus.

As the disease advances there develops also an extensive perivascular fibrosis involving vein, artery and nerve, all of which may become matted together in a fibrous cord. It is probable that this involvement of the nerve in a chronic fibroblastic inflammatory process accounts for the excruciating pains to which victims of this disease are occasionally subject. Proceeding *pari passu* with the occlusion of the larger vessels by intimal proliferation and thrombosis there develops a collateral circulation (Fig. 79) which for varying periods of time provides an adequate circulation for the ordinary nutrition of the part below the occlusion and undoubtedly helps to explain the great chronicity of the disease and the delay in the development of gangrene.

**Symptoms and Signs.**—The subjective and objective symptoms of thromboangiitis obliterans are those common to nutritional ischemia of whatever origin. Subjectively, the most frequent symptom is pain varying from slight discomfort in a foot or leg—at times mistakenly attributed to flatfoot, varicose veins or arthritis—to an intolerable demoralizing pain for which only amputation provides relief. In some patients comparative comfort is secured only by complete rest and the slightest exertion produces painful and incapacitating 'cramp', sometimes located in the toes, ankle, calf and even thigh. This sequence of painful limping accompanying exercise with relief from pain when at rest is known as *intermittent claudication* and is probably related to the greater production, incomplete removal and therefore increased accumulation of lactic acid in anoxic and ill nourished tissues.

In other patients further comfort is experienced during a day of limited exertion but at night is approached with dread because of the terrors of so-called 'rest' pain relieved at times only by lying with the affected leg hung over the side of the bed. Its absence during moderate exercise is ascribed to the assistance to circulation which comes from muscular compression of the larger veins.

Other painful sensations of thromboangiitis are described as a soreness, an aching in the muscles, a persistent and increasing burning, a numbness or just coldness of

the toes, foot or lower leg. Easy and excessive fatigability of the affected extremity may be an early symptom.

The objective signs are no less characteristic and if properly sought for and observed should prevent such erroneous diagnoses as fallen arches, rheumatism and subcutaneous infections. Early in the course of the disease there appears the phenomenon of edematous pallor on elevation of a limb above the cardiac level and deep redness or cyanosis on standing erect. When associated with absent pulsation in the posterior tibial and dorsalis pedis arteries this phenomenon of pallor and rubor depending on position is diagnostic of an occlusive vascular disease and the degree of such pallor and rubor roughly indicates the degree of vascular occlusion. So closely do the redness

large calloused areas and small areas of dry gangrene (Fig. 80). Small nodosities along the line of the superficial veins probably represent involvement of the valves in the course of the veins. Vasomotor phenomena such as sudden pallor in one or more digits accompanied by numbness or dull discomfort may occur following exposure to cold and may disappear entirely following massage and heat. Edema occurs in the late stages of the chronic type of disease and occasionally early in the acute type in which gangrene is an early development requiring amputation. Amputation through an edematous area is absolutely contraindicated as it results in a non-healing stump and reamputation is invariably necessary.

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Fig. 80—Trophic changes of the nails and circumscribed gangrene of the fingertips in a case of thromboangiitis obliterans involving both upper and lower extremities.

and pain suggest infection that the diagnosis of a deep-seated abscess is sometimes erroneously made for which an ill-advised operation is performed and from which non-healing wounds result. Similarly slight injuries such as blisters from shoes or cuts from prying the nail and accidental abrasions result in non-healing wounds. Such breaks in the protection afforded by the skin permit the entrance of pyogenic organisms into poorly vascularized and therefore poorly nourished areas resulting in great accentuation of all symptoms, particularly pain. Non-healing infected wounds are frequently the precursors of gangrene.

Phlebitis of the superficial veins is considered by Buerger as one of the characteristic features of this disease. Other so-called trophic lesions may develop such as shallow indolent ulcers, hypertrophied toe nails,

### III. ARTERIOSCLEROSIS

Arteriosclerosis is an important cause of circulatory disturbances in advancing age due to a slowly progressive narrowing and obstruction of the peripheral vessels largely through a proliferative overgrowth of the intima and degenerative changes characterized by the deposition of fatty and atheromatous material in the arterial wall. Scar tissue and calcareous deposits replace the fatty deposits and the vessel loses its normal elasticity. The formerly plastic vessel becomes progressively more rigid and more contracted, increasing stagnation of the blood stream follows and varying degrees of thrombosis occur to increase the narrowing of the circulatory bed.

These changes are very slowly though inevitably progressive and unlike thromboangiitis obliterans take place more uni-



formly throughout the peripheral bed (Fig 81) The collateral circulation is minimal and remissions rarely occur

The usual symptoms of ischemia are present—paresthesias and numbness of the digits, sensitiveness to cold, intermittent claudication appearing after shorter and shorter periods of exercise, intolerable pains while at rest, non-healing fissures and wound, stubborn infections, the trophic changes of dry skin, calluses and hypertrophied nails, pallor on elevation, rubor in the dependent position and absent pulsation in vessels all make their appearance in greater or less degree over a period of months—sometimes years. During the period of progressive ar-

teriosclerosis has been ascribed to anemia of the spinal cord. Experimental confirmation of this explanation has been developed by Reichert, who was able to produce the same evidence of weakness and intermittent claudication in the legs of dogs by ligation of the abdominal aorta or of the lumbar segmental arteries that supply the lower portion of the spinal cord. Reichert was also able to produce unilateral claudication by unilateral occlusion of the lumbar segmental arteries. This syndrome should be borne in mind in elderly persons with marked arteriosclerosis and a history of intermittent claudication in the thighs but without marked evidence of peripheral vascular occlusion.



Fig 81—Injection of the arteries (a) of the normal vascular bed and (b) in arteriosclerosis showing the closure of the large vessels and the absence of a collateral bed. Compare with Fig 79 (Reichert).

terial occlusion the patient may secure comfort only by progressively restricting his activities within the limits of his circulation.

An occasional arterio-sclerotic patient is encountered whose complaint of weakness in the thighs coming on after walking a short distance accompanied by cramps limited to the thighs or a feeling of tightness in the muscles of the legs suggests peripheral vascular occlusion. Examination of the vessels, however, shows pulsation to be present though in diminished degree associated with definite neurological disturbances such as hyperreflexic reflexes and difficulties with sphincter control. Roentgenograms of the pelvis will reveal marked arteriosclerosis of the abdominal aorta. The symptoms have

**Diabetic Arteriosclerosis**—The underlying pathologic changes occurring in gangrene complicating diabetes are (1) a more or less advanced arteriosclerosis and (2) thrombosis in already diseased vessels by the introduction of infection through abrasions or minor wounds of the skin. Hence the extraordinary care that must be devoted to the feet in the elderly diabetic patient, so as to avoid injury or chafing and thus prevent the entrance of organisms into tissues ill prepared to combat them. When gangrene occurs on an arteriosclerotic basis amputation must be done at a higher level than when the gangrenous process is largely due to infection. When good pulsations are present in the posterior tibial and dorsalis pedis

arteries gangrenous digits may be amputated locally in the hope that control of the diabetes by insulin will arrest the infection and permit healing. Adequate drainage of infected fascial spaces supplemented by control of the diabetes may completely arrest the process.

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#### IV SYPHILITIC ENDARTHRITIS

Occasionally widespread changes which are directly attributable to syphilis occur in the arterial wall of comparatively young persons. Marked round cell infiltration of the media, fragmentation and destruction of the elastic lamellae, overgrowth of the intima and finally secondary thrombosis are noted. All changes which eventually obstruct the lumen of vessels and produce the characteristic signs and symptoms of vascular deficiency. In addition to the usual treatment of peripheral vascular occlusion which will be outlined presently, treatment of the causative factor, syphilis, is in order.

#### V VASOSPASM COMPLICATING ARTERIAL OCCLUSION

An important feature of peripheral vascular disease, particularly thromboangitis, which has led to profound modification of its treatment in the past few years is that in many instances diminished circulation is due as much to functional occlusion by vasoconstriction as it is to organic changes in the arteries. This vasospasm apparently involves not only the partially occluded vessels but also the collateral vessels. It is considered to be a reflex response to noxious impulses having their origin in the inflammatory process involving the arteries and the accompanying nerves. Vasomotor phenomena such as sudden pallor in one or more digits, numbness and dull discomfort may occur after exposure to cold and may disappear entirely after massage and heat treatment. The close resemblance to the vasomotor disturbances of Raynaud's disease has made it difficult at times to state whether a given condition should be classified as one of well advanced Raynaud's disorder with incipient gangrene or as a case of early thromboangitis which is in the pre-gangrenous stages.

Many tests have been devised to ascertain the degree of vasospasm complicating organic occlusion. Typhoid vaccine administered intravenously produces a chill and fever and generalized vasodilatation including the affected extremity. The temperature of the great toe is determined with a Tyco's dermaterm. It varies normally from 90° to 33° C, the oral temperature being 37° C. In vascular occlusion the temperature of the toe may be as low as 20° to 25° C. After the administration of typhoid vaccine the oral temperature may rise from 37° to 39° C, but owing to the vasodilatory effect of generalized fever the temperature of the toe may rise from 25° to 30° C. This indicates a marked degree of vasospasm.

Spinal anesthesia will relieve the vasoconstriction imposed by an overactive sympathetic system. Paravertebral block of the lumbar ganglia following injection of novocain will also interrupt the sympathetic nerves to the lower extremities as will also the blocking of peripheral nerves with novocain.

The simplest method available is that described by Landis. After the skin temperature of the great toe has been taken both arms are immersed for thirty-five minutes in an arm bath of water at a temperature of 43° to 45° C. Generalized vasodilatation is induced and the temperature of the toe is again taken after ten minutes. If the digital temperature rises above 30° C organic occlusion of the blood vessels is definitely excluded. If the digital temperature fails to rise or rising fails to reach 32° C the presence of organic obstruction is indicated. In the presence of other evidences of organic occlusion the degree of vasospasm is determined by the degree of rise in the temperature of the big toe which occurs following warming the hands.

#### TREATMENT OF PERIPHERAL VASCULAR OCCLUSION

Certain general precautions must be observed by every patient. Never again should he disregard the facts that his arteries are clogged, that his only hope of avoiding amputation lies in being able to develop a collateral circulation sufficient for ordinary needs and that he must be content to restrict his activity within the limits of the

available circulation. Chilling of even a limited part of the body is dangerous, cold or chilled hands or head will evoke vasoconstriction in the feet, just as vasodilatation of the hands produces vasodilatation of the feet. Each time such vasoconstriction occurs some permanent damage to tissues may result by precipitating an extension of the existing thrombosis. The patient is instructed to wear warm overshoes preferably fur lined and fur lined leggings in severely cold weather. Warm gloves to avoid chilled fingers and the proper protection of the head, ears and neck are stressed. Woolen socks and comfortably large shoes should be worn loosely laced over the dorsum of the foot.

At the first recognition of a vascular disorder attention should be directed toward meticulous care of the feet guarding them against trauma against injury while nails or corns are being pared and against the injury of ill advised minor surgical procedures such as the opening of a supposed abscess. The skin is washed daily, gently dried and rubbed with lanolin. Slight cuts or abrasions are washed with soap and water dried and covered with a small sterile dressing. The use of strong antiseptics such as iodine, lysol or cresol, is indicated instead a 1 per cent aqueous solution of gentian violet is prescribed for home use. Any injury or abrasion however slight, should be under a physician's care until healed. An infected wound requires careful supervision and rest in bed until healed.

The patient with thromboangitis has a diminished blood volume and an increased blood viscosity. Every effort should be made to increase the volume and diminish the viscosity by the ingestion of a large amount of water 3 or 4 quarts daily by actual measurement and daily charting. For the acutely ill patient requiring hospitalization Silbert finds great help by administering 300 cc of a 5 per cent solution of sodium chloride intravenously every other day for several weeks. Repetition of the course may be in order after an interval of one or two months.

The patient is taught by actual observation the optimum position in which the foot is neither too pallid because of too great elevation nor too cyanotic because of too great dependency (Reid). Superficial veins should be neither collapsed nor distended. When lying down the patient should attempt to approximate this optimum position and when sitting he should elevate his legs on a chair in front of him whether at home in his office or out riding.

Baerger's simple exercises should be performed two or three times a day. Elevation of the foot for one minute, a horizontal position for three minutes and a dependent position over the edge of the bed for two minutes. When the leg is in a horizontal or dependent position the toes and ankle should be flexed thus aiding the return flow of blood by the muscular compression of veins. The patient is cautioned against standing in one position and when it is necessary to stand he

should move his toes and ankles constantly to assist the circulation.

Optimum nutrition is mandatory. The patient should be given explicit directions concerning a high vitamin diet containing plenty of fresh uncooked vegetables and fruits, butter and milk, haliver oil capsules, brewers yeast tablets and lemon juice are prescribed. If the patient has a low blood pressure the basal metabolism rate is determined, thyroid is administered if the rate is less than minus 5. Anemia is corrected by the necessary nutritional elements including liver and iron.

Tobacco in any form is absolutely prohibited. Experiments on normal subjects regarding the effects of smoking have shown a decrease in peripheral blood flow ranging from 57 to 83 per cent, with a corresponding drop in peripheral skin temperature the average drop being 5.3° F and the maximum drop 15.5° F. A slowing and actual stoppage of blood flow in the capillaries of the nailfold have also been observed (Lampson, Wright and Moffat).

The patient is taught the value of producing twice daily a generalized vasodilatation by immersing the arms in water heated to 49° C or 108° F (Landis and Gibbon). The same vasodilatory effect may be obtained by the application of an electric heating pad over the abdomen for thirty to sixty minutes once or twice a day (Wright).

Additional measures depend on the complicating features of the vascular occlusion. The patient with threatened gangrene in toe or toes and with a painful open wound must be put to bed preferably in a hospital and kept there until the crisis is past or the wound has healed. As Reid suggests such a patient can well afford in order to save his limb and probably his life to spend six, eight or twelve months in an effort to restore his vascular equilibrium. Various measures are available before resort is made to radical treatment by amputation.

Intermittent venous hyperemia produced twice daily for thirty minutes by the alternate inflation and deflation of a blood pressure cuff applied to the thighs as described by Collens, Wilensky and de Takats, will have a beneficial effect. The pressure of the inflated cuff should not exceed the diastolic level, and the length of inflation should be determined by the appearance of definite rubor in the foot, usually within two or three minutes. The period of deflation should be double the period of inflation followed by one minute of elevation of the limb. The average cycle would then, be two minutes of compression, three minutes of release and one minute of elevation.

Intense pain may be controlled by crushing selected peripheral nerves exposed under local anesthesia. The posterior tibial nerve, the deep and superficial peroneal nerves and the sural nerves may be crushed singly or in combination. The exposure and crushing of nerves should never be done in the presence of lymphangitis nor near areas of phlebitis and should be done with a minimum of operative trauma (Smithwick and White).

In the presence of both arterial occlusion and large varicosities of the superficial saphenous system saphenous ligation and injection of the veins with 20 per cent salt solution may give beneficial results.

In a patient with marked vasospasm permanent interruption of the lumbar sympathetic chain may be effected either by operation or by injection with 95

per cent alcohol (Flathow and Reichert). The efficacy of such a procedure should first be determined by temporary interruption of the lumbar sympathetic nerves with novocain. The degree of comfort and increased range of walking obtained by such a temporary interruption are sometimes remarkable. The interruption may be made permanent by the injection of 1 or 2 cc of 95 per cent alcohol.

The injection of typhoid vaccine to produce vasodilatation is contraindicated in advanced arteriosclerosis because of the danger of thrombosis during the period of peripheral vasoconstriction that precedes the fever and dilatation (Allen). For a young adult with thromboangitis it is an excellent agent if performed with the patient in a hospital bed preceded by active vasodilatation through overheating. In the first dose 25-600 000 bacteria may be given increased by 50 000 000 with each dose until 300 000 000 are given at a time. Injections are given at intervals of four to seven days until 6 to 8 injections have been given. The course may be repeated in two or three months. The patient should be admitted to the hospital for at least a day for each injection.

The treatment of inadequate circulation in the extremities by alternate suction and compression as developed by Landis Reid and Herrmann seems to have its greatest usefulness in acute arterial occlusion due to embolism. The improvement in appearance and comfort of an ischemic limb when placed in a special boot (the pavaex boot) designed to provide alternately negative and positive pressure is startling. Its efficacy in thromboangitis has not been clearly demonstrated although in the absence of open infected lesions or of active thrombophlebitis it may provide some improvement. Its use is contraindicated in the presence of open infected areas as the massage of inflamed tissues causes unbearable pain and leads to a spread of the inflammation. Definite though often temporary improvement has been demonstrated after its use in arteriosclerotic ischemia. Caution is again indicated in the presence of open infected lesions.

Reasoning that the failure of the pavaex boot to improve circulation may be due to its inability to influence already obliterated channels a suction and pressure chamber was developed for application to the thigh where vessels are supposedly more easily influenced by external forces (Holman and Schulte). Within the cylinder pressures of +30 to +50 mm and -60 to -70 mm of mercury are alternately produced every five seconds. The cylinder can be applied to the thigh without harm or pain in the presence of open lesions on the toes or feet and has been found more effective than the pavaex boot in improving comfort and circulation.

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## ERYTHROMELALGIA

(Functional Hyperemia Weir Mitchell's Disease)

Erythromelalgia is a rare affection usually of the feet characterized by pain flushing and local heat made far worse if the parts hang down. It is attributed to excessive vasodilatation and is thought by some to be the opposite of Raynaud's disease. Full, bounding pulsation may be felt in the vessels of the affected foot. The skin is flushed and warm. Elevation and the application of cold are the known remedies. The condition warrants consideration only to call attention to the fact that peripheral vascular occlusion is also accompanied by a painful rubor, but the affected part is *cold not warm* both objectively and subjectively. On the theory that it is a disturbance in the sympathetic control of the blood vessels Reichert has abolished their control by alcoholic injection of the lumbar sympathetic ganglia with definite improvement in comfort.

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## AMPUTATIONS IN PERIPHERAL VASCULAR DISEASE

When amputation is found necessary for intractable pain or for advancing gangrene the choice of a site for such amputation is a difficult matter.

Much depends upon the cause of the gangrene whether entirely circulatory in origin or due to a combination of infection and vascular occlusion (McKuttrick). In the presence of advancing infection delay in amputation may be fatal. The site of ampu-

tation is usually above the knee. On the other hand in a case of gangrene and infection limited to one or two toes with a palpable popliteal pulse the toes are amputated locally and accessory measures as already described are taken to improve the circulation.

In gangrene of the foot without serious infection and with a palpable popliteal pulse amputation below the knee may be attempted although it must be recognized that such an attempt is unsuccessful in about 20 per cent of cases. When the popliteal artery is not palpable a Callander amputation through the femoral condyles or preferably a very low thigh amputation may be attempted if vascular occlusion is due to arteriosclerosis. If due to thromboangitis the collateral circulation may warrant amputation below the knee. Clots found at operation in the main vessel may be removed by the introduction of a soft rubber catheter through which salt solution is introduced and the clots washed out.

Assistance in determining the site for amputation may be gained through the hyperemic test of Moschcowicz. The affected limb is elevated long enough to obtain pallor of the skin. A broad elastic bandage is applied as high as possible and sufficiently tight to obstruct the artery. This remains in place for from three to five minutes. When it is removed a hyperemic blush spreads rapidly down the surface of the thigh but only within the well vascularized area. Pallor persists where the vascular supply is inadequate. Amputation should not be carried out through any pale areas of skin. The Moschcowicz test should *never* be performed in a limb deprived of its circulation except under conditions which permit immediate amputation. The test may precipitate or greatly accelerate gangrene.

In performing amputations for gangrene or incipient gangrene the use of a tourniquet is absolutely contraindicated (1) because of danger of traumatizing already diseased vessels and precipitating thrombosis at the site of compression and (2) because of fear of causing death of tissues already deprived of adequate nutrition. The greatest gentleness is observed in handling tissues and individual bleeding vessels are grasped with small arterial clamps rather

than with large hemostats so as to avoid strangulating large masses of muscle or fatty tissue. The less traumatized and dead tissue in a wound the more apt it is to heal by first intention. Sutures in muscle are unnecessary and only a few need to be placed in the fascia. The skin is loosely approximated without drainage.

In cases of gangrene of the leg in elderly debilitated patients amputation is most safely performed under refrigeration anesthesia. The entire leg is surrounded with ice bags for two and one half to three and one-half hours when anesthesia is usually complete. For the very aged patient refrigeration may be curtailed to one or two hours and supplementary gas anesthesia employed. In the presence of gangrene and infection refrigeration may be applied immediately upon the patient's admission to the hospital while further studies are being completed. Refrigeration keeps the infection in abeyance, prevents further toxemia and minimizes shock when amputation is done.

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#### ANEURYSMS

Once forming a frequent problem in a surgeon's practice aneurysms are becoming more or less rare and give promise of occurring even less frequently. The more adequate treatment of syphilis may account for this change.

An aneurysm is a pulsating sac containing liquid or coagulated blood or both and is directly connected with the lumen of an artery. Such a sac may be the result of injury to the artery—a traumatic aneurysm. It may also follow the disintegrating action of syphilis or of arteriosclerosis on the arterial wall resulting in the so-called spontaneous idiopathic or pathologic aneurysm. In such a case the media, the strong elastic coat of the artery, has been destroyed and replaced by fibrous tissue or

calcareous deposits. Under the stress of exertion or emotion the intra-arterial pressure may be greatly increased and the scarred wall may give way to form a fusiform swelling in the course of the artery, the intima and adventitia of which may still be intact. This is known as a *true aneurysm*. However, such an increase in intra-arterial pressure may also produce a pouch projecting from the side of the artery which gradually enlarges and which may even burst into the perivascular tissues to form a *false* or *sacculated aneurysm*. Rarely in the thoracic aorta the giving way of the intima and media permits the blood to escape from the lumen into a potential space between layers of the media, thus resulting in a dissecting aneurysm which follows along the course of the artery for a variable distance. Left to itself an aneurysm invariably continues to expand and death occurs either from pressure on some vital structure or from massive external or internal hemorrhage. As the aneurysmal dilatation approaches the skin it may present all the evidences of inflammation and abscess. Rarely spontaneous cure occurs due to clotting of the stagnant stream in the aneurysmal sac, a fortuitous event which practitioners in the past have attempted to encourage by the so-called *Valley* treatment, the essentials of which were absolute rest, starvation, blood letting and abstention from fluids.

*Mycotic Aneurysm*.—An infected embolus may give rise to a localized abscess, particularly if it has its origin in the periphery and lodges in the brain where abscess or meningitis may develop. Small clumps of bacteria originating in vegetations of the endocardium accompanying bacterial endocarditis may lodge in the vasa vasorum of large arteries producing destruction of the arterial wall and the development of a so-called *mycotic aneurysm*. Occasionally multiple dilatations due to mycotic aneurysms occur. On rare occasions the infectious process beginning in the wall of the artery involves also the contiguous vein and a mycotic arteriovenous aneurysm is the result.

*Symptoms*.—Symptoms are extremely variable depending on the location and size of the aneurysm. The most frequent site is in the thoracic aorta where it may produce pain from an erosion of vertebral ribs or

sternum dyspnea and cough from pressure on the air passages hoarseness from paralysis of the left recurrent laryngeal nerve due to pressure or stretching as it passes under the arch of the aorta Aneurysms of the ascending aorta may cause incompetence of the aortic valves with all the symptoms of regurgitation including collapsing pulse and cardiac hypertrophy In contrast with the remarkable dilatations of the heart observed as a sequence to an arteriovenous aneurysm the fusiform or sacculated aneurysm has in itself little effect on the heart unless it happens also to produce aortic incompetence An associated generalized arteriosclerosis may be the cause of the cardiac hypertrophy erroneously ascribed to the aneurysm A thoracic aneurysm may rupture into the thorax into the trachea or externally through the skin Rupture of an aneurysm into a cavity may produce great pallor intense weakness unconsciousness and finally death

Innominate subclavian and carotid aneurysms present in the neck where localized pressure on the brachial plexus may produce sensory or motor paralysis of the arm Pressure on the cervical sympathetic plexus may produce Horner's syndrome namely a contracted pupil and a narrowed palpebral fissure Vertigo faintness and attacks of unconsciousness may accompany a carotid aneurysm

Aneurysms of the internal carotid within the skull may produce symptoms of a brain tumor Numbness of the face unilateral oculomotor palsies and headache should suggest an intracranial aneurysm of the internal carotid artery (Symonds)

Aneurysms of the extremities because of their accessibility exhibit distinctive features The swelling is not only pulsating but expansile *i.e.* palpation by the two index fingers shows separation of the fingers with each systole of the heart Pressure on the artery above the aneurysm may cause almost complete disappearance of the swelling The blood pressure readings below the aneurysm are lower than similar readings on the unaffected side

Aneurysms of the femoral or popliteal arteries may interfere with venous and lymphatic return and produce swelling of the limb Diminished circulation below the aneu-

rysm may produce symptoms of peripheral ischemia such as absent pulsation intermittent claudication and rest pain The popliteal aneurysm which may be the result of the constant trauma of flexion and extension on a rigid arteriosclerotic arterial wall is often accompanied by considerable pain and disability on walking

Aneurysms usually exhibit on auscultation an interrupted bruit which may be systolic only or both systolic and diastolic with a definite hiatus between the two phases

**Differential Diagnosis**—Highly vascular tumors such as certain sarcomas simulate aneurysms so exactly even to the production of systolic bruits that the differential diagnosis is difficult A tumor of the carotid body which is highly vascular and uniquely situated between the branches of the common carotid artery is frequently diagnosed as a carotid aneurysm

A cyst or tumor over a large vessel may transmit such a vigorous pulsation that it is difficult to rule out aneurysm

Great care must be exercised in differentiating a simple aneurysm from an arteriovenous aneurysm inasmuch as ligation of the artery proximal to the latter lesion—on the basis of a mistaken diagnosis of simple aneurysm—will in most instances lead to real circulatory embarrassment if not to gangrene of the extremity The continuous thrill and bruit the prominence of veins in the neighborhood of the fistula the slowing of the pulse and increase in blood pressure on closing the fistula by digital compression or on compressing the artery proximal to the aneurysmal mass should serve to identify the arteriovenous lesion The blood pressure and pulse are unaffected by closing the artery proximal to a simple aneurysm

**Treatment**—Medical measures designed to decrease intra arterial pressure and promote spontaneous clotting by stagnation of the blood stream are usually unsuccessful Limitation of foods and fluids and complete rest may relieve pain but do not cure the lesion The various methods of ligation of the artery proximal to the aneurysm depend on a decreased pressure and clotting within the sac for their curative effect a result not always achieved because of the development of collateral circulation Historically specific

names have become identified with certain ligations. Antyllus a Roman of the third century is credited with having ligated the vessel proximal and distal to the aneurysmal sac following which the sac was opened and evacuated. Acl of Toulouse in 1710 described ligating the artery just proximal to the sac whereas in 1786 John Hunter first employed his classical operation in Hunter's canal for a popliteal aneurysm. Acl's ligation is performed at a site likely to be involved in the pathologic process whereas the hunterian ligation is performed at a point where the vessel wall is normal thus reducing the danger of erosion of the wall and secondary hemorrhage at the site of the ligation.

sac by scratching it with long fine needles introduced from without. Clotting is accelerated thereby and may be used with or without ligation of the artery proximal to the aneurysm.

All ligations have an inherent defect—they do not attack the aneurysmal sac directly. Extirpation of the sac has been repeatedly advocated but the dangers are real. Adjacent structures such as nerves may be so intimately bound to the sac that its excision would endanger the distal nerve supply. Moreover such excision would also endanger the collaterals present in the tissues surrounding the aneurysm. Both the defects are remedied by the excellent operation of Matas first used by him in 1889.

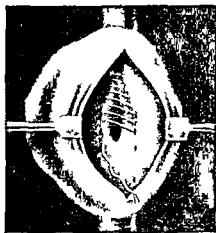
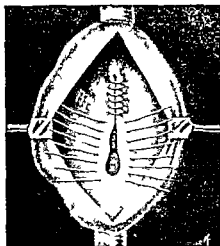


Fig 82—Aneurysmorrhaphy according to Matas. A Obliteration of aneurysmal sac by successive layers of sutures. B Restoration of arterial lumen by closure of abnormal opening and obliteration of sac.

Brasdor a French surgeon in 1760 advised ligating the artery distal to the aneurysm. If there are no branches of the vessel between the aneurysm and the distal ligation this should be an excellent procedure inasmuch as Halsted has shown that there is very little pulsation in the part of the vessel lying between the ligature and the first branch proximal to the ligature. This being true there should be little pulsation in the aneurysmal sac which lies proximal to the ligature. Distal ligation is applicable to aneurysms of the aorta and the three innominate carotid and subclavian arteries.

Macewen of Glasgow suggested traumatizing the inner surface of the aneurysmal

sac and since applied with remarkable success in many hundreds of cases (Fig 82). The operation depends on the feasibility of completely controlling all circulation through the sac by the application of a tourniquet or by the application of arterial clamps to the vessel proximal to the sac. In the case of a fusiform aneurysm the sac is boldly opened the clots are removed and both arterial orifices and all branch openings are closed by individual transfixion ligatures. The sac is then obliterated by successive rows of ligatures applied to the sac. This he entitled the *obliterative enloaneurysmorrhaphy*. The sacculated aneurysm is also boldly entered and occasionally the opening from the artery itself can be sutured and



its closure reinforced by suturing the walls of the sac over it. This was called *restorative endoaneurysmorrhaphy*. When preservation of the main channel would seem necessary for the life of the limb Matsis advocated the *reconstructive endoaneurysmorrhaphy*. The continuity of the parent artery may be restored by making a new channel out of the sac walls which can be brought together by suture over a guide (catheter or drainage tube) inserted into the proximal and distal openings of the aneurysm. Before the last suture is tied the guide is removed and the channel is left behind corresponding to the outline of the original artery. Even though such a passage may ultimately close by clotting the temporary assistance to circulation through this restored artery may be sufficient to prevent gangrene.

Operations for the cure of a carotid aneurysm are attended by the danger of fatal interference with the nutrition of the brain particularly in adults. Halsted therefore devised the method of partially occluding the large vessels proximal to the aneurysm by the application of an aluminum band which could be removed subsequently if hemiplegia of the opposite side gave evidence of cerebral anemia. Erosion of the arterial wall under the aluminum band is an ever present danger. Less dangerous is a narrow strip from the fascia lata which may be employed for partial occlusion by wrapping it twice around the artery and suturing the ends together (Brooks). The same precautions concerning the ligation of arteries should be observed as were enumerated earlier.

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#### VARICOSE VEINS

**Definition.**—Tortuous segmental dilations of veins may occur anywhere in the body. Some such as varices of the upper extremities and of the central nervous system, esophageal varices in portal hypertension, varices of the broad ligament and urinary bladder, the varices of the spermatic

veins as varicocele and the enlargement of the rectal veins as hemorrhoids may produce characteristic clinical symptoms. In this discussion however only the superficial venous system of the lower extremities, namely the involvement of the saphenous network, will be considered (Fig. 83).

**Incidence.**—It is difficult to estimate the incidence of varicose veins with a fair degree of accuracy. However in a thorough examination of 1000 young healthy industrial



Fig. 83.—Infra red photograph of lower extremities. There is a valvular incompetence between the right long saphenous vein and the deep venous system below the knee. Above the knee and over the entire left leg the normal subcutaneous pattern of the saphenous system is well visualized. With the exception of a small varicosity on the right calf, no veins were visible in an ordinary photograph.

workers, 10 per cent were found to have been affected. Varicose veins were noted in 40.7 per cent of the men and 73.2 per cent of the women employed in a large department store (536 employees). All were over forty years of age.<sup>1</sup>

**Etiology.**—The saphenous network has been put to an unusual strain through the erect posture of man. Adaptation to the erect posture is accomplished by means of many valves which relieve the lower ex-

tremitics from venous backflow. That the adaptation is not uniformly adequate is shown by the marked variations in the number and position of the valves. In addition the anatomic course of the saphenous vein deprives them of an important aid in venous return, namely the milking effect of muscular activity. As the veins are unsupported between the skin and the fascial layer an increased venous pressure may readily produce anatomic changes.

Heredity seems to be important in the development of varicose veins. A constitutional weakness of the connective tissue is often seen in patients afflicted with varicose veins. Such patients have hernias, flat feet, frequent nosebleeds because of varicosities of the nasal septum or cutaneous nevus; they are asthenic and have a low blood pressure. If both parents are afflicted their children usually have varicose veins in the early twenties.

A second factor in the production of varicose veins is the undue strain of prolonged motionless standing on the saphenous system. Thus waiters, laundresses, street car conductors and policemen are predisposed by occupation and their existing varicosities are aggravated. Other causes for increasing venous hypertension are traumatic rupture of valves constricting garters, pressure of enlarged lymph glands or pelvic organs straining with constipation and pregnancy. This last factor is so important that it requires further elaboration. Pregnancy interferes with the venous backflow from the lower extremity by the pressure of the greatly enlarged uterus on the iliac veins. But more important than this is the greatly increased volume of venous blood flowing from the hypogastric vein which produces a relative incompetence and obstruction in the external iliac vein. Thus varicose veins may become manifest and painful in the first third of pregnancy when the size of the uterus could hardly account for the venous obstruction.

Finally the effect of postpartum postoperative or postinfectious thrombophlebitis on the development of varicosities must be considered. The obstructive clot may be manifest or latent according to its extent and location but it will produce a new collateral circulation with the formation of

varicosities of atypical course. The clots may be in any segment of the venous system including the veins of the calf and thigh muscles. If this clot later canalizes and the circulation is re-established there still remains the effect of the destruction of important valves in the veins. The patient then suffers from a valvular incompetence with resulting postural venous hypertension.

Accordingly the following factors are important in the etiology of varicose veins: heredity, trauma, increased postural strain, compression or constriction of veins and phlebitis which may destroy valves in the superficial or deep venous system. All of these factors induce a postural venous hypertension of the lower extremities which is the pathologic equivalent of varicose veins. Whether the valvular incompetence is primary or not, it is directly responsible for the pooling of blood in the dependent extremities.

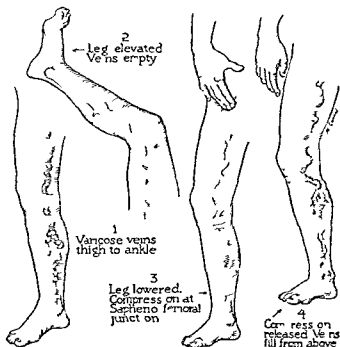
**Pathology.**—The changes encountered in varicose veins are the results of increased venous pressure on a muscular tube which first responds with hypertrophy and later with dilatation, elongation and tortuosity. There is a more or less constant inflammatory reaction in and around the walls of varicose veins indicating that bacteria which were in the blood stream have lodged in the sluggish pools where drainage is slow and incomplete. The thinning and saccular or spindle shaped dilatation of the veins occurs at first just proximal to the valves and then spreads distally. As a result of the loss of muscular elements by continuous distention and often infection a fibrosis or even a sclerosis with lime deposits takes place. The phlebo sclerosis in senility is an analogous to arteriosclerosis and gives a striking x-ray picture of the lime deposits.

When the venous stasis spreads from the large veins into the subcutaneous network or into the intradermal subpapillary plexus the so-called spider bursts or rocket bursts appear. A supramalleolar cyanosis seen often in women of asthenic slender build and endocrine dysfunction such as low metabolic rate and scant menstrual flow is a sign of such progressive venous insufficiency. It is markedly aggravated in pregnancy.

**Symptomatology**—The early symptoms of progressive venous insufficiency are a tired heavy sensation in the legs cramping of the calves at night or in cold water and swelling of the ankle or dorsum of the foot. When the venous dilatations reach a certain stage the pressure and traction on the accompanying saphenous nerve may produce painful radiation along the course of the nerve. The extent of the varicosities by no means parallels the severity of symptoms as enormous dilatations are often

blood in the dilated veins is arterial in character this being recognized by the light red color of oxygenated blood. Compensatory venous dilatations following deep venous thrombosis are not true varicose veins and do not follow the course of the internal and external saphenous veins but show atypical convolutions chiefly on the lateral aspect of the thigh lower leg and dorsum of the foot.

A most important error is to diagnose varicose veins as a cause of complaints when



TRENDELENBURG TEST

Fig 81—Trendelenburg test. The leg is first elevated to empty the vein and constriction is applied. Then pressure is exerted to collapse only the superficial veins. The patient then stands up. If the pressure is maintained. Note the collapse of the veins. If the vein does not collapse when pressure is applied at the groin it may still be made to collapse when pressure is applied at lower levels below incompetent communicating valves on the thigh. The fourth sketch shows the leg immediately after the pressure of the hand has been released. Note the sudden filling of the veins from above.

symptomless and a few hardly palpable varicosities may produce much discomfort. Most of the symptoms however are due to complications such as phlebitis ulceration eczema or superimposed skin infection.

**Diagnosis**—If every dilated vein on the lower extremities is regarded as a varicose vein and treated as such grave mistakes may occur. Multiple arteriovenous fistulas are easily mistaken for varicose veins. These are congenital slowly progressive lesions. The affected limb is warmer and sometimes larger than its fellow and the

other conditions are responsible for the symptoms presented. Thus static deformities flatfoot genu valgum sacroileal or lumbosacral arthritis spondylolisthesis or true scurvy may be overlooked in the presence of a few insignificant varices. Almost any traumatic infectious or neoplastic disease may simulate the vague symptoms of varicosities and may be overlooked during a superficial examination.

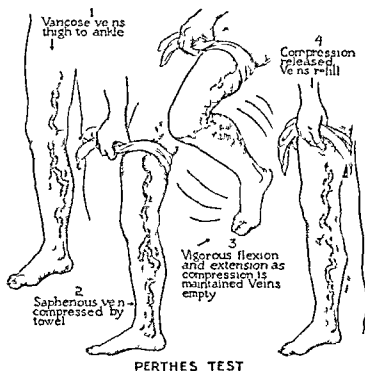
Soft fluctuating easily compressible masses on the lower extremities may be diagnosed erroneously as varicose veins. Of

these, femoral hernia the rare lymphocele and small muscle hernias which occur on the lateral aspect of the lower leg in young athletic persons should be mentioned.

A diagnosis of varicose veins is not complete until the condition of the superficial and communicating valves and the patency of the deep veins are determined. The Trendelenburg test (Fig 84) gives information regarding (a) the incompetence of the saphenous valves and (b) the efficiency of the communicating valves at different levels.

ciency, it requires more intensive treatment and is more likely to recur.

The patency of deep veins is tested by the method of Perthes (Fig 84). Following constriction of the saphenous trunk by a tourniquet vigorous muscular exercise is carried out; blood is sucked into the deep veins and the superficial varicosities collapse. When the pressure is released the filling from above demonstrates the amount of blood aspirated into the deep veins. If the deep veins are not patent or if there is



PERTHES TEST

Fig 85.—Perthes test. A tourniquet is applied at different levels with the patient in the standing position. Vigorous flexion and extension of the knee is carried out ten times. Note how the veins collapse after exercise, indicating patency of the deep veins. When the pressure is released the veins suddenly fill from above. The tourniquet may be placed around the thigh at different levels and thus localizes the level of incompetent valves in the communicating veins.

When after elevation and digital or circular compression of the saphenous trunk the veins in the calf remain collapsed in the standing position, one has good evidence that reflux of venous blood occurs only from above, i.e. through the saphenofemoral junction and not from the deep veins through the communicating branches. When however in spite of saphenous compression the veins of the calf suddenly fill when the erect posture is assumed the communicating valves are incompetent. This is a more advanced stage of venous insufficiency,

an increased venous pressure in the deep veins on standing; no diminution of the superficial veins will take place. The test not only denotes patency of the deep veins when the veins collapse during exercise but also localizes the site of incompetent veins on the thigh when applied at different levels. Thus it becomes a modification of Mahomed and Oelsner's comparative tourniquet test.<sup>3</sup>

Deep venous obstruction results from ascent to the iliofemoral segment of propagating thrombi from the deep and communicating veins in the foot and calf. This

groin Their greatest usefulness is in chronic indurated ulcers or postphlebotic indurations and they may be readily combined with surgical measures to reduce back pressure

Treatment by rest in bed elevation and hot boric acid dressings may become necessary in acutely inflamed ulcers The ulcers harbor many bacteria An azochloramide-sulfanilamide powder in an alkaline buffer is very helpful in clearing up this infection Within a few days however the patient may get up and walk Muscular contractions of the calf muscles and tight even pressure obtained by marine or rubber sponges under an elastic adhesive dressing will promote healing in a large percentage of ulcerations Should the ulcer fail to heal under such management one must consider (1) a disturbance of arterial circulation evidenced by absent or diminished pulses drop in skin temperature dependent rubor and pallor on elevation (2) the presence of a non varicose ulcer such as a thrombo phlebotic traumatic luetic mycotic or trophic ulcer or (3) the extensive induration around the ulcer which interferes with blood supply and the size of the defect which is not apt to heal spontaneously In the latter case excision of the ulcer and skin grafts are necessary Iontophoresis with histamine mecholyl or sodium chloride may help to soften the induration around the ulcer but is a very slow and cumbersome process

*Injection Treatment*—The injection of irritating substances producing endophlebitis thrombosis and obliteration of varicose veins is indicated for ambulatory patients There are few but definite contraindications to this form of treatment<sup>6</sup> Certain systemic diseases such as a history of cardiovascular accident (angina pectoris cerebral thrombosis) hyperthyroidism active tuberculosis and acute infections of any sort prohibit the use of this method which may aggravate or activate the quiescent lesion An acute cold or tonsillitis in addition may produce thrombophlebitis originating at the site of injection Of the local conditions the lack of patent deep veins (see description of Perthes test) and the presence of a manifest or latent infection either in the deep or in the superficial veins are the definite con

traindications The solutions used are 50 per cent dextrose 15 to 30 per cent sodium chloride a mixture of 50 per cent dextrose and 30 per cent sodium chloride various concentrations of invert sugar sodium salicylate quinine and urethane and 5 to 10 per cent solutions of sodium morrhuate or potassium oleate The action of all these solutions is physicochemical injury to the endothelium of the vein which responds with an outpouring of fibrinous exudate and rapid organization of a mixed thrombus One should postulate for such a solution that it must be (1) non toxic in the amounts used (2) effective (3) not too painful and (4) not capable of producing extensive sloughs or (5) drug hypersensitivity While the ideal solution has not been found potassium oleate in 5 or 10 per cent solution injected in from two to four segments at a time in quantities of from 0.5 to 2 cc is the writer's choice at the present time

The criticism of this method is that while it readily obliterates visible and palpable segments below the knee and occasionally above the knee it does not reliably interrupt back pressure from the highest segment of the internal saphenous vein or from incompetent perforating veins and therefore is equivalent to local excision of varicose segments which is likely to be followed by recurrence Sloughs can usually be avoided by meticulous care in eliminating paravenous injections Should they occur immediate injection of the patient's own blood into the blanched area is helpful The fully developed slough is best excised followed by primary suture

*Surgical Procedures*—High ligation of the saphenous vein is first systematically employed to interrupt back pressure from above by Trendelenburg can be done under local anesthesia for ambulatory patients<sup>7</sup> With a hockey stick incision placed one-third above and two thirds below Poupart's ligament the internal saphenous vein is exposed doubly tied and cut The ligature is placed as close to the saphenofemoral junction as possible All tributaries entering the saphenous vein at or below the junction must be cut between ligatures (Fig 85) Failure to ligate the saphenous vein flush with its femoral junction results in complete canalization of the main trunk (Fig 86)

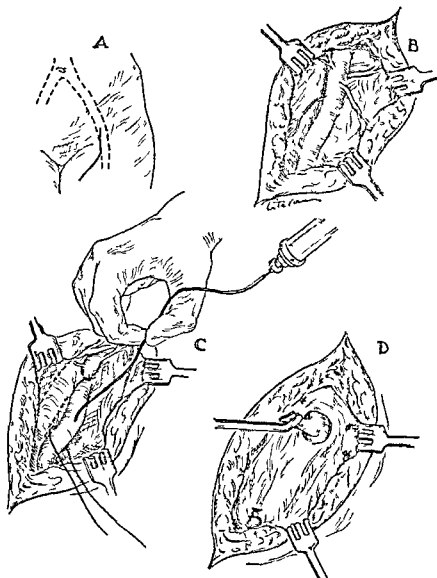


Fig 88—High ligation of the long saphenous vein with retrograde injection. *A* The line of incision is marked out after careful soap and water preparation the night before. With a 2 per cent aqueous solution of brilliant green the line is drawn over the pulsation of the femoral artery gently curving medially 1 inch below and parallel with the inguinal ligament. This incision provides a good exposure of the saphenofemoral junction. *B* The superficial fascia has been split. The main saphenous trunk is exposed with several tributaries whose pattern is variable. *C* Two No 20 cotton ligatures are placed 1 inch apart. The proximal ligature is tied, the distal is left loose and is used for traction when a No 18 urethral catheter is inserted into the vein. The catheter is marked in inches so that the length of the catheter which can be passed into the distal segment can be measured. The catheter may often pass as far as 26 to 30 inches into the vein. On its slow withdrawal approx 1 cc of sclerosing solution is injected for each inch of venous segment. The solution used is 50 per cent dextrose in 20 per cent salt solution. *D* After the catheter is withdrawn the distal stump is tied and a transfixion ligature is placed proximal to it. Then the proximal stump is grasped with a curved hemostat and all tributaries entering the vein between the proximal stump and its junction with the femoral are doubly tied with No 40 cotton and cut. Finally the fossa ovalis and the femoral vein proximally and distally to the junction are exposed and a No 20 cotton ligature is placed flush with the junction. No saphenous pocket must be left since a thrombus may form and break loose. Distal to the ligature the vein is transfixed with a suture-ligature to insure against slipping. The subcutaneous fascia is carefully closed with No 60 cotton sutures and the skin is closed with interrupted black cotton sutures. In hot weather sulfanilamide is applied distal to the line of suture and the dressing secured by three to four strips of elastic adhesive tape.

The ligatures are anchored by transfixion sutures to insure against slipping. The ambulatory, high saphenous vein ligation may

be carried out on all patients who show a visible or palpable reflux from above on the thigh and whose deep veins are patent. The

operation is also done on patients with varicose ulcers provided there is no acute infection present. It reduces the percentage of recurrences, reduces the number of necessary injections and serves as an efficient barrier against embolism should an ascending thrombosis develop in the saphenous vein and spread toward its junction with the femoral vein.

In the absence of any latent phlebitis (discussed in the following section) a sclerosing solution is injected into the distal



Fig 80—Ligation of the long saphenous vein was done with a transverse incision too low to catch some of the tributaries. Two years later the patient presented a complete recurrence in the saphenous vein and its tributaries. The recurrence occurred through the unligated tributaries. The line of incision and the visible tributaries are marked with mercurochrome. Such cases require reoperation.

stump at the time of the operation. A ureteral catheter passed gently as far as it will go evenly distributes 90 to 30 cc of a dextrose salt mixture. This usually obliterates the segment of saphenous vein to the knee. Injections are then continued a week later below the knee.

High saphenous ligation followed by injection treatment is the method of choice at present. Faulty technique of ligation overlooked incompetent communicating valves or incompetent short saphenous veins and

unrecognized damage to the deep venous circulation are responsible for the failures of this method.<sup>8</sup> In a small percentage of cases multiple incompetent communicating veins below the knee may call for their subfascial ligation.<sup>9</sup>

After treatment following any type of procedure should consist of frequent inspection of the patient during the first few years. Small recanalizations or new varicosities can be easily resected. If the patient's occupation can be changed to one which is conducive to less mechanical strain the chances of permanent cure are enhanced.

GEZA de TAKATS

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### VENOUS THROMBOSIS

The true incidence of thrombi in the vascular tree is easily underestimated since small segmental clots need not produce clinical symptoms. Even the pathologist may miss them unless he makes a deliberate search in certain areas which are usually not examined in a routine postmortem examination. The plantar veins of the foot and veins of the calf muscle harbor thrombi in 50 to 60 per cent of all adults.<sup>1</sup> The pelvic veins are frequently filled with phlebotiths visible in roentgenograms. The broad ligament when transected during hysterectomy

toxy, often contains plugged veins. The exact incidence of pelvic thrombi including those in the large vesical, uterine, prostatic and rectal plexuses has never been accurately estimated. While the majority of thrombi occur in the lower extremities and the pelvis, the upper extremity and any visceral organ may contain silent thrombotic areas which may become the starting point of massive clinically manifest occlusions.

**Etiology.**—Three factors, namely, slowing of the circulation, trauma to the intima and increased tendency to clotting can be readily recognized as being responsible for the localization and production of intravascular clotting. Many other contributory or predisposing factors operate through these three main channels.

**1 Slowing of Circulation.**—When circulating blood slows down its corpuscular elements group themselves into a central axial current containing mainly red cells, the white blood cells take a more peripheral position whereas the platelets seem to travel at the periphery, sweeping the intimal surface. Clumping of platelets or adherence to the intima can immediately take place whenever a raw surface is encountered. Nevertheless, stagnation of blood alone need not give rise to thrombosis. Blood may stay liquid in a vein between two ligatures if care is taken not to injure the intima, but when other factors are present the ligatures will serve to localize the clot to a certain segment. The postoperative state and the slow circulation time of the cardiac patient predispose to thrombosis; the constricting action of ligaments and tendinous insertions may determine the localization of the thrombus. Thus the lateral plantar veins of the foot are crossed and readily compressed by the plantaris longus tendon, the upper margin of the soleus muscle or Poupert's ligament has a retarding action on venous return especially in certain positions. The left common iliac vein possesses a congenital stricture, thus explaining the more frequent involvement of the left lower extremity.<sup>2</sup>

**2 Injury to the Intima.**—Mechanical trauma such as tearing or stretching of a vessel is responsible for thromboses following sprains, fractures, gunshot wounds and stab wounds. The vessel itself does not have

to be cut through to show injury of the endothelial lining. But here again the bruise of the lining alone will not suffice to produce a massive propagating thrombus unless another factor, namely, the outpouring of tissue juice is added. Injury to the intima also occurs in infectious or degenerative lesions of the vessel wall interfering with the nutrition of the inner coat. Such lesions are encountered in infectious arteritis and phlebitis in Buerger's disease or at the site of subintimal atheromatous plaques which ulcerate and produce sessile thrombi on their roughened surface. Vascular sensitization seems to play an important role in setting up an allergic inflammation notably present in periarthritis nodosa;<sup>3</sup> such a lesion may terminate in thrombosis or the formation of small aneurysms. Aneurysms themselves whether congenital, traumatic or infectious are a frequent source of mural thrombi which occasionally lead to spontaneous obliteration of the sac.<sup>4</sup>

**3 Increased Tendency to Clotting.**—There are many conditions which produce increased coagulability of the blood. Loss of plasma in burns and in secondary shock, dehydration due to vomiting and rapid diuresis after use of mercurials produce hemoconcentration and increased viscosity. The same is true in patients with polycythemia whose clotting tendency is notorious. Fundamentally any lesion which liberates thrombokinasase will accelerate blood clotting. This occurs after injuries to tissues especially muscles, massive wounds of the extremities or surgical trauma produce increased coagulability. In the blood itself the destruction of platelets liberates thrombokinasase so that every agglutination thrombus of platelets carries in itself a nucleus for further spread of thrombosis. Patients suffering from carcinomatosis<sup>5</sup> or from excessive digitalization<sup>6</sup> show an acceleration of the clotting mechanism.

**Prevention of Thrombosis.**—Increased attention to the three factors just described may help to decrease the incidence of thrombosis. Postoperatively the patient should be placed in a Trendelenburg position (6 to 8 inches of elevation of the foot of the bed). He should be encouraged to take regular breathing exercises and he should flex and extend his foot and calf mus-



cles many times a day. He should not be kept in bed any longer than absolutely necessary. Statistics amply prove that with identical groups of patients those who are ambulatory earlier show a lower incidence of thrombosis. Obviously all such measures have their contraindications and limitations.

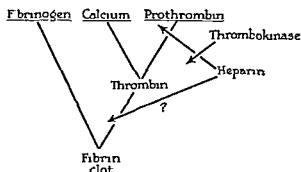


Fig 90—Note that heparin acts by counteracting the effect of thrombinase and by preventing the conversion of prothrombin to thrombin. Whether heparin also acts on the second phase of clotting, namely the conversion of thrombin into fibrin, is doubtful.\*

Trauma of course whether mechanical, thermal or bacterial is impossible to prevent but once it affects the vessel by thrombosis the propagation of the clot can be arrested by measures to be discussed in the next paragraph.

bleeding time may reveal some changes but are not sensitive enough. Since heparin acts by inhibiting the first phase of blood clotting (Fig 90) the individual's response to heparin can be used to measure the amount of clotting factors in the blood. Ten milligrams of heparin will produce a typical curve in the normal individual when such a curve is flattened, he either harbors thrombi or at least his blood is more readily coagulable so that he requires increased protection (Fig 91).

Whether such clotting really runs in families is uncertain but it is known that some operations and some preoperative conditions carry an incidence of thrombosis that is higher than average. A patient who undergoes laparotomy, prostatectomy or an operation on or fracture of the hip especially if he is old or obese is in the endangered group. If he has previously had a thrombosis the risk is approximately doubled.<sup>9</sup> Such a patient is entitled to the prophylactic administration of heparin or dicoumarol (See the section on Treatment).

**Pathology**—Thrombi are classified as being hyaline, red or white. The first are found in smaller vessels and represent glassy fibrinoid masses occurring as a result of toxic

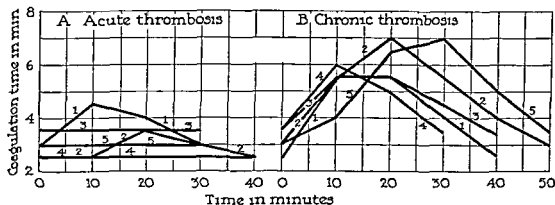


Fig 91—Note that in cases of acute thrombosis the response to 10 m<sup>g</sup> of heparin is either absent or very poor, whereas in the chronic cases the same amount of heparin produces a marked increase in the coagulation time over the period of forty minutes. The flattening of these heparin curves is also observed in the first few days after a major operation, after sudden dehydration or after toxic losses of digests.<sup>†</sup>

Excessive coagulability of the blood can be counteracted by the judicious use of anti-coagulants.<sup>8</sup> In order to use such drugs in their proper place there is need for simple rapid detection of an increased clotting tendency. The customary clotting time and

injuries to the intima. They may become the seat of superimposed red, white or mixed clots.

Red thrombi occur as a result of the coagulation of stagnating blood. They are practically identical with a postmortem clot.

\* de Takats, Surg. Gynec. & Obst. 77.

† de Takats, Surg. Gynec. & Obst. 77.

and consist of large masses of red cells and some leukocytes embedded in a network of fibrin. Their surface is smooth, their consistency soft and spongy, and they are rarely adherent to the vessel wall, at least in the early days of their formation. They occur secondarily following the formation of a white clot which produces an obstruction to the blood flow and liberates massive amounts of thrombokinase. Red thrombi are most important from the standpoint of embolism.

White thrombi, in contradistinction to the red thrombi, occur in the circulating blood and typify the agglutination thrombi of platelets. The platelet thrombus is soon covered by a layer of leukocytes and fibrin, thus giving rise to the white or leukocyte thrombus. Their surface is rough and granular, and they are much firmer and contain less water than do the red thrombi. They adhere firmly to the wall of the vessel at the site of an intimal lesion.

*Progression of Thrombi.*—The white thrombus, commonly called the *head* of the thrombus, if it obstructs the vessel completely, may give rise to a superimposed red thrombus, the *tail* of which may lie in the veins either peripherally to the head of the clot, in which case it obstructs distally important collaterals, or centrally, in which case the end may become loose and produce an embolus. Usually there is a transitional segment between the head and tail, a mixed thrombus consisting of the mixture of red and white thrombi. When the tail of a thrombus breaks off, another red thrombus may quickly reform. This propagating thrombus, whether it forms in the vein or in the artery, is the most significant complication of intravascular clotting.

*Symptomatology.*—No attempt will be made here to discuss the symptomatology of visceral thrombosis, only venous occlusions of the upper and lower extremities and of the pelvis will be described.

*A. Thrombosis of the Upper Extremity.*—*Axillary thrombosis* (thrombosis on effort) affects muscular young men, who after sudden, violent exertion, experience a sharp pain in the axilla or anterior chest wall, followed by swelling and cyanosis of the entire upper extremity. If not relieved by appropriate measures, the swelling becomes rather

fixed. The superficial veins stand out prominently, and a cutaneous network of collaterals develops over the shoulder girdle. If the arm is exercised, it becomes numb and painful, and the venous pressure visibly increases in the superficial veins. The obstruction is usually in the subpectoral segment of the subclavian vein, where it becomes compressed between the anterior chest wall and the costocoracoid fascia. The level of obstruction and the extent of the collateral circulation can be readily visualized by inject-



Fig. 92.—Roentgenogram of a young man who suddenly developed pain and swelling of the right arm during basket ball practice. After injection of 20 cc of diodrast into a prominent cubital vein complete block of the third portion of the subclavian vein just below the clavicle becomes apparent. Collateral circulation was evident over the shoulder and scapula.

ing radio-opaque solution, such as 35 per cent diodrast, into a superficial vein at the elbow. A roentgenogram is obtained of the axillary region within thirty seconds (Fig. 92).

While this lesion is obviously of traumatic origin, other factors, such as infectious periphlebitis originating from an infected hand or a polycythemia resulting in increased coagulability, have been recognized as contributory causes.

Another type of axillary venous thrombosis is encountered following radical mastec-

tomy for carcinoma of the breast. The marked edema of the arm following such an operation may be due to lymphatic or venous obstruction or to a combination of the two.<sup>10</sup>

Because of the extensive use of intra-venous injections and continuous drips the superficial veins at the elbow or on the dorsum of the hand not infrequently show a short segmental thrombus which is of little import unless it shows proximal spread toward the axilla. In such cases marked periphlebitic induration is also manifest. Emboli from such a source are most unlikely. More serious is a perivenous leak from some irritating solution toward the median nerve which may give rise to a long lasting cruralgic state.<sup>11</sup>

### *B Thromboses of the Lower Extremity*

—1 THROMBOSIS OF SUPERFICIAL VEINS—Varicose veins frequently harbor a latent infection and slight trauma, the puncture of a needle or the introduction of a sclerosing solution may reactivate a resting infection.<sup>12</sup> In other cases the infection is frankly hematogenous originating in an infected tonsil or tooth and often following their removal. The large clots are hot and tender; they may start at any point but usually have an ascending character. The temperature and white blood cell count are seldom elevated and the leg shows no diffuse swelling except for localized edema around the inflamed vein.

A migrating segmental phlebitis of superficial veins that were previously not enlarged is highly suspicious of thromboangitis obliterans (See section on Thromboangitis Obliterans). Large superficial varicosities may also become thrombosed in the presence of an old deep venous obstruction. Such thromboses may affect the collateral venous pattern of the lower part of the leg, thigh and anterior abdominal wall.

2 THROMBOSIS OF THE DEEP VEINS OF THE FOOT AND LOWER PART OF THE LEG—The plantar veins of the foot and the veins of the calf muscle harbor small thrombi in approximately half the adult population. Such clots become clinically manifest when they grow by apposition following the appearance of some other factor such as trauma, infection, immobilization or increased coagulability of the blood. In throm-

bosis of the plantar vein the sole of the foot especially the lateral side is tender to pressure. Later the tenderness may be elicited over the inner malleolus and still later along the course of the posterior tibial vein. Pain and muscle spasm in the calf are noted when the foot is dorsiflexed (Homans sign).<sup>13</sup> The temperature of the skin over the calf muscles is elevated if an oscillogeter is available it frequently reveals increased pulse waves over this area. The process may extend into the popliteal vein after which edema becomes manifest. Otherwise because of the abundance of deep veins in the lower part of the leg swelling does not appear. Hanging both feet over the edge of the bed for several minutes may reveal a cyanotic hue on the affected side.

Visualization of the deep veins of the lower part of the leg by radio opaque substances is unnecessary in the majority of cases. Only when a pulmonary embolus has formed and the source of the embolus is not apparent by simple clinical methods should such a diagnostic procedure be undertaken even so the interpretation of the films at this area is often inconclusive (Fig 93).

*Iliofemoral thrombosis* is well known as milk leg. The clot has now ascended from the calf through Hunter's canal to the inguinal ligament or has extended from the hypogastric vein to its fusion with the external iliac vein. It practically never seems to form primarily at this level. There is sudden pain at the groin with diminution of arterial pulsation within twenty-four hours. Edema develops at first showing more of a venous cyanotic color and readily pitting later being a hard white lymphatic type of swelling. Unless adequately treated the occlusion may extend to the other limb in a high percentage of cases. Embolism from this level is infrequent.<sup>9</sup> Such thrombi usually occur several days after the onset of thrombosis in the plantar veins in the muscles of the calf or in the pelvic veins. Close attention to the early signs and symptoms may avert the clinical picture of full blown iliofemoral thrombosis.

*Thrombosis of the Pelvic Veins*—A glance at the wide tortuous sinuses of the hypogastric vein, their difficult drainage over the several concavities, their proximity to frequently infected organs such as the blad-

der, uterus, prostate and rectum, explain the frequency of phleboliths in the roentgenograms and the mobilization of such clots after surgical procedures. The clinical symptoms of pelvic thromboses are vague, but they relate to the organs which they accompany. There may be pain and swelling of the buttocks or in the adductor muscles close to the inguinal fold. Sciatic neuritis is characteristic of a thrombosed sciatic vein. Frequency of urination or rectal spasm may denote thrombosis of the perivesical or hemorrhoidal plexus, but obviously this symptom may signify many other conditions. More characteristic are slight suprapubic edema or palpable cords lateral to the uterus or prostate. Emboli are not infrequent as long as the thrombosis is intrapelvic and therefore clinically more or less silent, but they are not so likely when the thrombus has extended to the common iliac vein and has produced a "milk leg."

There are, of course, combinations and transitions from one group to another. Generally speaking, the more latent and bland the thrombus, the more readily it breaks loose. In fact, approximately 40 per cent of pulmonary emboli appear before the primary source becomes evident.<sup>14</sup> Whether one can always differentiate between an infectious thrombophlebitis and a non-infected phlebotrombosis<sup>15</sup> is doubtful. A traumatic or mildly infected thrombus may ascend as a bland, non-adherent clot which breaks loose easily. A bland phlebotrombosis can develop into an inflammatory periphlebitis when it reaches the inguinal lymphatics, which frequently harbor infection. The amount of edema accompanying thrombosis depends on the extent of the blocked collaterals, on the periphlebitic lymphatic obstruction and on the vaso-spasm accompanying the venous occlusion. They may all be present in the same patient in varying proportions.

**Treatment.**—The objectives of treatment are threefold: first, to localize the clot to the site at which it becomes manifest, second, to minimize or inhibit the formation of persistent edema, and, third, to prevent passing of single or recurrent emboli to the lung. All methods of treatment must be viewed with these three objectives in mind.

1. *Elevation*—Raising the foot of the bed

on high blocks or on two chairs helps venous and lymphatic drainage from the lower extremities and pelvis. A pillow under the knee and lower part of the leg angulates the popliteal and iliofemoral segments and is worse than the horizontal position. The up-



Fig. 93.—This patient exhibited marked incompetence of the perforator veins in the calf without any edema and without any history of a thrombotic episode. Opaque substance demonstrates large sacular veins in the muscles and under the skin. The deep veins show a ragged contour and a sudden decrease in the lumen just below the popliteal fossa. The diagnosis of deep venous obstruction is corroborated by this film.

per extremity can be hung from a Balkan frame or elevated on pillows.

2. *Bed Rest*—In cases of superficial phlebitis or in deep venous obstructions, which have been excluded from the circulation by division of the vein proximal to the clot, bed rest may be necessary for only a few days until the pain subsides. In a typ-

ical case of milk leg the pulse and temperature must be normal for ten days before the patient is allowed out of bed

3 *Heat*—Heat cridles or hot fomentations relieve pain but are apt to increase the edema. The skin may blister easily with moderate heat. Ice packs frequently employed are also not harmless since tissue injury may occur. A snug elastic compression from toes to groin allowing free muscular movement is preferable.

4 *Mercurial Diuretics*—Mercupurin from 0.5 to 2 cc given intravenously especially

phlebitis. Its use is limited to cases in which there are superficial streaks of phlebitis which are hot and very painful to touch and to cases of iliofemoral thrombosis with inguinal pain and lymphadenopathy. The treatment is thus directed purely against the periphlebitis. Nothing is known about its action on the clot itself.

6 *Anticoagulants*—Heparin is now available in pure form and is comparatively free of reactions except that sensitization may occur.<sup>17</sup> It can be administered by continuous intravenous drip given in such doses

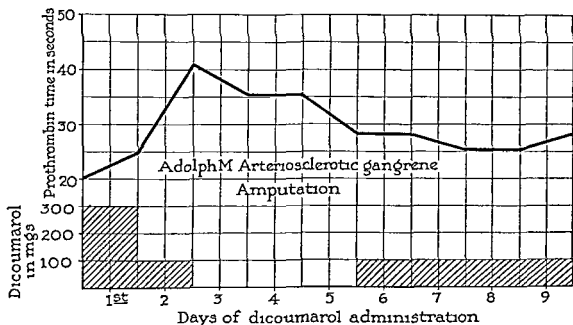


Fig 94—This patient received 300 mg of dicoumarol the first day and 200 mg of dicoumarol the second day after amputation. On the third day the prothrombin time was lengthened to 50 per cent of normal and nothing was given until the end of the fifth postoperative day when 100 mg was used daily to maintain a somewhat higher than normal level of prothrombin. In elderly arteriosclerotic patients who may bleed easily from undetected sources such as the kidney, prostate or gastrointestinal tract, it is wiser not to maintain the customary levels of 60 to 80 per cent of the normal prothrombin time. This patient was moving about freely in a chair on the fifth day and was discharged on the tenth day following operation.

if preceded by acidifying drugs such as ammonium chloride or ammonium nitrate decreases thrombophlebitic edema very effectively.<sup>16</sup> However if the patient is suddenly dehydrated his blood may clot more readily thus assisting propagation of the thrombus. Since safer methods are available use of this drug does not seem necessary.

5 *X Ray Therapy*—Small doses of x rays not exceeding 100 r and administered with a heavy filter at intervals of one week hasten the absorption of the periphlebitic exudate and decrease the size of the enlarged lymph glands which may accompany

that an eight to ten minute capillary coagulation time (three times the normal level) is maintained. It is equally effective and simpler to give 50 mg (5 cc) intravenously every four hours; the coagulation time may be determined once an hour for the first period to determine the varying tolerance of the patient to the drug.<sup>17</sup> Simultaneously with the administration of heparin the oral use of dicoumarol is started 300 mg the first day and 200 mg the second day. On the third day the use of heparin can be discontinued since the lagging action of the extract of spoiled sweet clover

(dicoumarol) now becomes apparent. The activity of dicoumarol is measured by daily determination of the prothrombin time. The prothrombin level must be kept between 50 and 30 per cent of the normal so as to keep the drug in effective, yet safe limits (Fig 94). Should the level sink to 20 per cent of normal or below normal blood transfusion or massive (100-200 mg.) doses of vitamin K may restore it to normal. Dicoumarol should never be administered without control of the prothrombin level. This type of anticoagulant therapy is used in all types of thrombosis as long as the patient is bedridden, this includes pulmonary emboli whose source is unknown or which cannot be plugged by proximal ligation such as for instance a right auricular thrombus. When a patient becomes ambulatory but shows recurrent attacks of thromboses, as a polycythemic patient may, doses of 300 mg. of dicoumarol a week, with at least one prothrombin determination a week are capable of checking such attacks.

**7 Paravertebral Sympathetic Block.**—Any vascular occlusion, whether arterial or venous produces vasospasm not only in the collateral vascular bed<sup>18</sup> but also in adjoining major vessels if they are wrapped in the same vascular sheath. Pain and edema in venous thrombosis are due in part to increased vasoconstriction in the affected limb, sometimes even in the contralateral limb, the degree of vasospasm seems to depend on the perivascular involvement, namely, that of the adventitial fibers. For this reason the bland, non-inflammatory thrombus produces much less vasomotor reaction than the irritative, inflammatory lesion. Most of the vasospasm is seen in the iliofemoral group, with an exudate within the vascular sheath which may abolish femoral pulsation entirely and give rise to a false diagnosis of acute arterial occlusion. In such cases the affected limb is colder, the pulsations are diminished or absent and a severe, vise like constriction is felt throughout the leg and thigh. The same picture is seen in axillary venous thrombosis. The block of the regional sympathetic produces a remarkable relief from these symptoms. The arterial and venous spasms disappear, the limb becomes warm and dry and the edema rapidly diminishes.

In many cases, however, there is an increase in temperature over the foot and lower part of the leg, in fact, this is one of the earliest symptoms of incipient thrombosis of the leg. The pulses are bounding, the oscillometer shows increased pulsations. Pain is slight or absent and seems to be due to the edema. In such cases there is no evidence of excessive vasoconstriction and sympathetic block is unnecessary.

The lumbar sympathetics are blocked with 1 per cent procaine to abolish vasomotor tone in the lower extremities (Fig 95). The patient is placed in a lateral position, the side of the injection uppermost. Three or four wheels are made 2 to 2½ fingerbreadths (perhaps 4 to 5 cm.) lateral to the midline and at the upper border of each spinous process beginning from above with the first Lach wheel should fall about over a transverse process. The wheels are made with procaine (1 per cent) and the aponeurosis is anesthetized. Each needle is first inserted about perpendicular to the plane of the back and should meet a transverse process at a depth of about 4 to 5 cm. (2 inches). It is then withdrawn to the level of the aponeurosis and redirected (higher or lower) more centrally at an angle of less than 20 degrees with the plane of the back. It is passed about 2 to 2½ fingerbreadths (4 to 5 cm.) deeper than the transverse process so that its point impinges against the vertebra in the retropleural space. When passed in this direction the point of the needle will remain lateral to the great vessels and may be reinserted to make contact with the vertebra more anteriorly. Through each of the four needles 5 to 10 cc. of solution is injected.

Sympathetic block is often useful in the late chronic type of thrombophlebotic edema exhibiting much pain and varied degree of swelling on different days a subject to changes in the weather. These patients have a chronic fibrous scar around the thrombosed vein maintaining various degrees of vasospasm. Before stripping or excision of such a vein is contemplated a few paravertebral sympathetic injections should be given as they may bring lasting relief.

For block of the upper extremity the patient is placed on his side, the head parallel with or lower than the neck and the side of the injection uppermost (Fig 96). A spot is selected 4 to 5 cm. lateral to the midline opposite the seventh cervical spinous process (for the injection above the first rib). A wheel is made and the muscular aponeurosis is anesthetized. The 9 cm. (4 inch) needle is introduced at an angle of 25 to 30 degrees with the plane of the back and somewhat caudad. It may strike at a depth of 5 to 6 cm. (1½ inches) the first rib or the transverse process of the seventh cervical vertebra. In such a case it must be redirected higher (more cephalad) or lower (caudad) as the case may be and at a point perhaps 2 cm. (1 inch) deeper than the rib should strike the side of the vertebral body. The needle must then be redirected in a slightly more lateral direction so that it scrapes the vertebral body. In any case it must pass with a depth of 2 mm. (about ½ inch) of the body lest the point enter the pleural cavity. Its point is passed about 1

cm ( $\frac{3}{8}$  inch) past its last contact with the vertebra. Suction on the needle must always be made to exclude bleeding or entry into pleura or lung. On injection of 10 cc of procaine solution vasodilatation should be rapid and Horner's syndrome is to be expected. Should

ing varicosities. The saphenous bulb may have to be cleared of thrombi by aspiration with a glass suction tube. Free flow of blood must be obtained from the femoral vein.

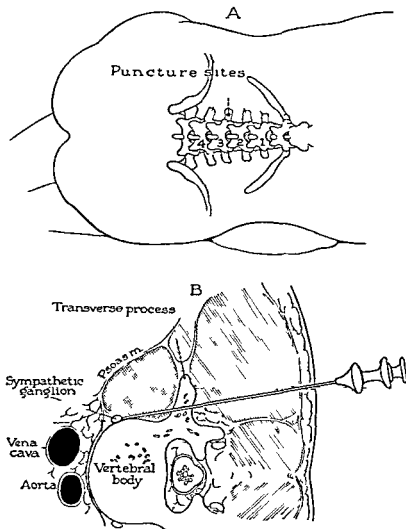


Fig. 20.—Paravertebral block of the lumbar sympathetic chain. The lumbar sympathetics are blocked with 1 per cent procaine to abolish vasomotor tone in the lower extremity. The patient is placed in a lateral position on the side to receive the injection uppermost. Three or four wheals are made  $\frac{1}{2}$  to  $\frac{1}{4}$  fingerbreadths (perhaps 4 to 5 cm) lateral to the midline and at the upper border of each spinous process beginning from above with the first. Each wheal should fall about over a transverse process. The wheals are made with procaine (1 per cent) and the anapneurosis is anesthetized. Each needle is first inserted about perpendicular to the plane of the back and should meet a transverse process at a depth of about 4 to 5 cm (2 inches). It is then withdrawn to the level of the aponeurosis and redirected (1/4 or lower) more centrally at an angle of less than 30 degrees with the plane of the back. It is passed about  $\frac{1}{2}$  to  $\frac{1}{4}$  fingerbreadths (1 to 5 cm) deeper than the transverse process so that its point impinges against the vertebra in the retroperitoneal space. When passed in this direction the point of the needle will remain lateral to the great vessels and may be reinserted to make contact with the vertebra more anteriorly. Five to 10 cc of solution is injected through each of the four needles.

procaine be injected into the lung the patient tastes it (salty flavor) very quickly.

**8 Division of the Vein Proximal to the Thrombus**—This is clearly indicated for the saphenous vein if thrombi occur in preexist-

ing division of the femoral vein below the profunda is indicated if a lower leg or popliteal thrombosis is diagnosed if there is no swell-

• Burns, Shock, Wound Healing and Vascular Injuries. Military Surgical Manual. National Research Council. W. B. Saunders Co. Philadelphia.

ing or tenderness in the thigh or if a pulmonary embolus has occurred and careful study reveals the primary source in the lower part of one of the legs [Fine<sup>19</sup> advocates ligation of the common femoral vein

of emboli from this source is low (6 to 7 per cent) The clot is in the process of organization and anticoagulant therapy holds it under reasonable control Whether ligation of the common iliac vein should be done

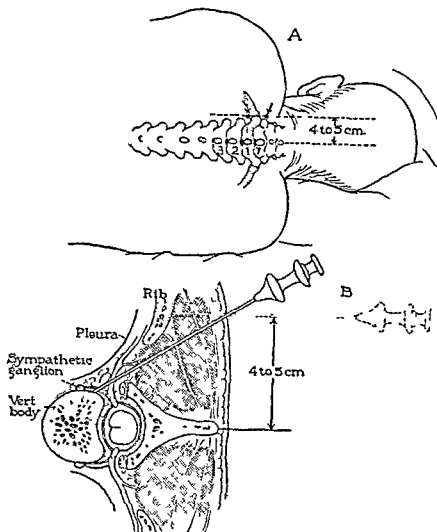


Fig 96—The paravertebral block of the upper dorsal sympathetic chain. For the block of the upper extremity the patient is placed on his side the head parallel with or lower than the neck, the side of the injection uppermost. A spot is selected 4 to 5 cm lateral to the midline opposite the seventh cervical spinous process (for the injection above the first rib). A wheal is made and the muscular aponeurosis is anesthetized. The 9 cm (1 inch) needle is introduced at an angle of 25 to 30 degrees with the plane of the back and somewhat caudad. It may strike at a depth of 3 to 4 cm (1½ inches), the first rib or the transverse process of the seventh cervical vertebra. In such a case it must be redirected higher (more cephalad) or lower (caudad) as the case may be and at a point perhaps 2 cm (¾ inch) deeper than the rib should strike the side of the vertebral body. The needle must then be directed in a slightly more lateral direction so that it scrapes by the vertebral body. In any case it must pass within about 2 mm (say 1½ inch) of the body lest the point enter the pleural cavity. Its point is passed about 1 cm (¾ inch) past its last contact with the vertebra. Suction on the needle must always be made to exclude bleeding or entry into pleura or lung. On injecting 10 cc of procaine solution vasodilatation should be rapid and Horner's syndrome is to be expected. Should procaine be injected into the lung the patient tastes it (salty flavor) very quickly.\*

—Ed.] However, if the clot is in the iliofemoral segment and especially if it is more than a few days old division of the femoral vein with aspiration of the proximal segment is of doubtful value. The percentage

in thrombi originating from the pelvis or extending high into the external iliac vein

\* Burns, Shock, Wound Healing and Vascular Injuries, Military Surgical Manual V, National Research Council W B Saunders Co., Philadelphia



except possibly elevation and splinting of the diaphragm. In milder forms the patient complains of sudden choking, dizziness and some dyspnea which however is fleeting or he may complain of upper abdominal cramps resembling those of pylorospasm or acute cholecystitis.

Gastrointestinal tract.<sup>2</sup> Morphine and digitalis having vagal effects facilitate these reflexes. Epinephrine may lead to pulmonary edema in the presence of hypertension in the pulmonary artery proximal to the obstruction. Atropine combined with papaverine blocks the reflexes and releases spasm of smooth

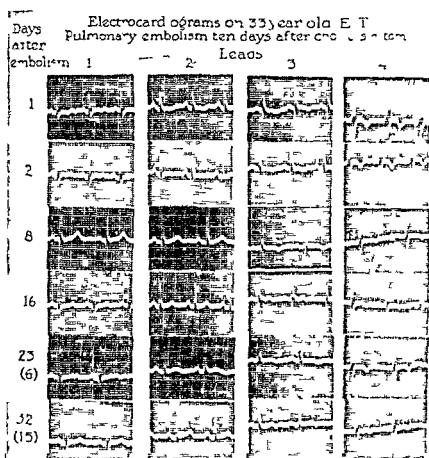


Fig. 97—Electrocardiograms of a woman aged 33 with pulmonary embolism ten days after cholecystectomy. One day after severe massive pulmonary embolism at auricular tachycardia  $T_1$  low  $T_2$  low  $T_3$  and  $T_4$  inverted deep  $Q_1$  QRS complex low in leads 1, 2 and 3. Two days after embolism auricular tachycardia  $T_1$  and  $T_2$  low  $T_3$  and  $T_4$  inverted deep  $Q_1$ . Eight days after embolism sinus rhythm  $T_2$  and  $T_4$  inverted marked improvement as compared with first tracing. Sixteen days after embolism auricular tachycardia deep  $Q_1$   $T_1$  and  $T_4$  depressed as compared with previous tracing the ST segment in lead 1 is more nearly normal. There is less depression of  $T_2$  and  $T_4$ . Twenty-three days after first six days after second embolism. As compared with previous tracing T waves are more depressed in all leads. Thirty-two days after first fifteen days after the second embolism sinus rhythm ST segment slightly elevated  $T_4$  inverted deep  $Q_1$  as compared with previous tracing  $T_1$   $T_2$  and  $T_3$  more nearly normal  $T_4$  still inverted marked improvement.\*

The mechanism of these widely spread and inconstant symptoms is shown in the diagram (Fig. 98). Following lodgment of a small embolus radiation of autonomic reflexes occurs which are predominantly vagal; there is vagal inhibition of the heart and coronary constriction; there is spasm of the unobstructed part of the pulmonary arterial tree of the bronchi and of the upper gas

muscle of the bronchi and the gastrointestinal tract. Both atropine and papaverine are potent coronary vasodilators; papaverine inhibits ventricular fibrillation; the ultimate cause of death in many such cases.

**Treatment.**—The treatment is obvious at the earliest suspicion of a pulmonary embolus: oxygen preferably 95 per cent must

\* de Takats, JAMA 111

be given by mask Atropine  $\frac{1}{15}$  to  $\frac{1}{60}$  gr and papaverine  $\frac{1}{2}$  gr are given intravenously and may be repeated every hour until the patient's condition improves. In

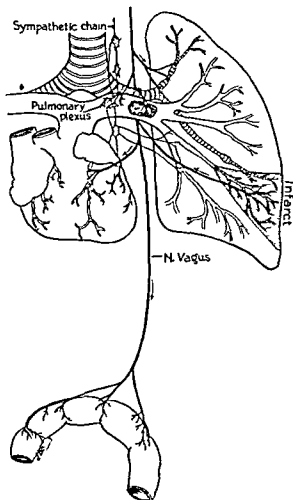


FIG. 95.—The afferent impulses travel mainly in the vagus nerve and radiate back to the lingual bronchomotor and bronchodilator fibers. They may constrict the coronaries, produce vagal inhibition of the heart and depress the blood pressure. They can radiate to the upper part of the gastrointestinal tract and produce colic, increased peristalsis and reverse peristalsis. The plug may produce stimulation of the sympathetic vasoconstrictors or a more general sympathetic stimulation on through the dilatation of the right heart (Bainbridge reflex). The hypertension in the right heart and in the pulmonary artery seems to be the main stimulus for these widespread reflexes, although the rise in intrapulmonary pressure, the congested lung and the irritated pleura all have been shown to act as reflexogenic factors.\*

case of death autopsy will reveal a small peripheral embolus and no acute coronary occlusion. Often however a myocardial infarct may be found due to acute coronary

insufficiency in a previously damaged heart.\*

Since a small embolus after the patient's survival of the initial attack may grow by apposition and may obstruct larger areas the use of anticoagulants is definitely indicated. Such treatment is equally beneficial against the primary source of the embolus which is sometimes obvious, sometimes suspected and often unknown. If the source of the embolus is in the calf muscles, division of the femoral vein distal to the profunda is indicated. If the thrombus is higher than that proximal division of the vein only seems indicated in the case of septic emboli. Pulmonary embolectomy if considered at all is reasonable only in the slowly fatal cases with increasing right heart failure.\*

**Sequelae.**—If the patient survives the initial attack there may develop a hemorrhagic infarct, pleurisy with effusion, atelectasis, pneumonia or even gangrene. For this reason roentgenograms are of little diagnostic aid since the typical wedge-shaped infarct is hardly ever encountered. Prophylactic use of moderate doses (60 to 90 gr) of sulfadiazine in all cases of pulmonary infarction is logical. Pleurisy with effusion or so-called virus pneumonia always should be regarded with suspicion when evidence of peripheral venous thrombosis is present.

### EMBOLISM OF PERIPHERAL ARTERIES

The main source of emboli in the peripheral arteries is in the left heart and less frequently in the aorta; the pulmonary veins need hardly be considered. Mitral stenosis and myocardial thrombi are the two most frequent heart lesions. A group of arterial thromboses occurs after operations, infectious diseases or artificially produced chill and may easily be thrust farther into the periphery of the arterial tree. Arterio-sclerotic plaques of the aorta may be the source of peripheral emboli.

Acute arterial occlusion produces motor and sensory paralysis. The skin is pale and clammy and the pulses are absent. Pain is not an early symptom and may be absent for many hours if the patient is immobilized. Should secondary venous thrombosis occur the limb becomes mottled or cyanotic.

The differential diagnosis between arterial

thrombosis and embolism is important from the standpoint of prognosis and therapy. Thrombosis usually comes on gradually. There is a history of previous symptoms due to arterial disease. On the other hand the history and presence of an organic heart lesion, the presence of some systemic infection or a postoperative status in a patient with cardiovascular disease or vasomotor collapse and the sudden onset of signs and symptoms of acute ischemia are unmistakably characteristic of arterial emboli. Occasionally differentiation between thrombosis and embolism is impossible.

The embolus usually becomes lodged at the major bifurcations of the peripheral arteries where the lumen of the vessel suddenly decreases. In 335 cases the incidence of emboli in the various locations was as follows: subclavian 2, axillary 18, brachial 40, radial 2, ulnar 1, aorta 34, common iliac 50, external iliac 10, common femoral 131, superficial femoral 11, popliteal 33 and posterior tibial 3.

**Prognosis**—This will depend on the cardiovascular status of the patient, on the extent of the collateral circulation at the obstructed level and on early diagnosis and early treatment. It must be remembered that not infrequently a second or third embolism of the extremities or of the cerebral, coronary or mesenteric vessels will cause the patient's death.

**Treatment**—Treatment of peripheral arterial embolism requires first accurate localization of the embolus. Knowledge of major arterial bifurcations, absence of pulses below and increased pulsations above the obstruction, occasionally the actual palpation of the clot or visualization by intra-arterial injection of opaque substances such as neostiodan are helpful. If the patient is seen within the first six to ten hours after the sudden onset of symptoms an attempt to extract the clot is warranted.

Successful embolectomy requires training in and equipment for the technique of arterial sutures. It is important to remember that only a few hours are required before secondary arterial thrombi may occlude the peripheral branches of the artery, thus annulling the effect of relieving the original obstruction. Also the vessel wall reacts to emboli so fast that a secondary thrombus

can occur at the site of the removed embolus. Nevertheless in a collective review of 296 cases 47 per cent of the embolectomies performed on the upper extremities, 40 per cent on the lower extremities and 91 per cent in the pelvis done in the first ten hours were successful.

Statistics collected in Sweden showed that of 382 patients on whom embolectomy was performed 60 per cent died, 20 per cent required amputation and 20 per cent left the hospital with a restored circulation. Follow-up studies showed that of this group three-fourths were alive one year, half of them three years and eighth of them ten years after the operation.<sup>4</sup>

Recently three important conservative measures have been advocated to prevent gangrene following peripheral arterial embolism. One is the intravenous use of papaverine in doses of from  $\frac{1}{4}$  to  $\frac{1}{2}$  gram three times a day, the other is institution of intermittent venous hyperemia. These measures used separately or preferably in combination with each other seem to act by relieving the massive collateral spasm which occurs when an artery is obstructed.<sup>5</sup> Paravertebral block of the sympathetics is the most efficient measure for enlarging the vascular bed to its capacity. If it fails to restore the temperature and the color of the limb, embolectomy is the method of choice in the first ten hours. Whatever type of treatment is chosen anticoagulants are urgently needed in order to prevent the occurrence of thrombosis distal to the embolus and the plugging of important collateral arteries.

#### FAT EMBOLISM

Mobilization of the body fat from certain depots such as the bone marrow or subcutaneous fat through the peripheral veins into the pulmonary circulation is the most frequent type of embolism. The chief source of fat embolism is the bone marrow. The following factors are necessary for the occurrence of fat embolism: (1) severe trauma which injures the fatty tissue and ruptures veins; (2) gassing of these veins which readily occurs in the veins surrounded by rigid bone and (3) a negative sucking action in the veins or a positive pressure from without supplied by a grow-

ing hematoma or inflammatory edema within the bony canal

All these factors are present following fracture of long bones. In addition, marrow fat has a lower melting point than tissue fat and therefore more readily liquefies. Outside of fractures, fat embolism has been known to occur in acute osteomyelitis or following injuries to other fatty depots of the body, but such cases are extremely rare.

The fat carried from the site of injury through the peripheral veins to the right heart is capable of passing through the capillaries of the lung and thus enters the general circulation. This depends on the

Of 112 fatal cases of fat embolism, 104 were due to fractures.<sup>11</sup> In 50 per cent of the cases, multiple fractures were present. The lung may show edema or punctate hemorrhages but the diagnosis is sometimes only made with the microscope (Fig 99). The accompanying shock of an injury with a resulting fall in blood pressure may make otherwise insignificant amounts of fat in the pulmonary capillaries the cause of death.

**Symptomatology.**—Clinical symptoms of dyspnea, cyanosis, cough and restlessness may occur several hours or days after the injury. The sputum may contain blood sediment droplets of fat. Moist râles and signs



Fig 99.—Fat embolism in a sixty year old man who suffered fractures of both scapulae and seven ribs on each side. He was very restless and dyspneic on admission. Thirty-one hours after the injury he suddenly expired. Photomicrograph shows fat droplets stained with osmium in a small artery at a bifurcation. (Courtesy of Dr. Edwin Hirsch, Pathologist to St. Luke's Hospital, Chicago.)

amount of the mobilized fat and on the blood pressure in the pulmonary artery. Several days sometimes elapsing before the fat passes through the pulmonary circulation. It need not necessarily produce symptoms and simply appears in the urine, or it may produce embolic occlusion and infarcts in any organ of which the brain, heart, kidney and skin are most important. It has been emphasized that fat floats on the surface of the urine and may not be detected unless the last few cubic centimeters of urine is expressed. In the presence of fat, a drop of urine heated on a wire loop sizzles.<sup>10</sup>

of pulmonary edema develop only after the right heart begins to fail. The pulse then becomes rapid, the blood pressure falls and cyanosis and later unconsciousness develop. The average duration of life in fatal cases of fat embolism is from two to three days. There may be, however, regression of symptoms to complete recovery, no matter how serious the initial symptoms.

The clinical symptoms of fat embolism in the systemic circulation are mainly cerebral and cardiac. There is usually an interval of several days between the manifestation of pulmonary and of cerebral symptoms or the patient is unconscious and the pulmon-

ary symptoms are not in evidence. The cerebral symptoms consist of a stage of somnolence, loss of memory or disorientation followed by a comatose stage with loss of reflexes, incontinence of stool and urine and finally death. In non-fatal cases which not infrequently occur following severe fractures only the first stage of somnolence or disorientation is seen. There may be punctate hemorrhages in the retina or in the skin.

**Diagnosis**—It is most important to differentiate between cerebral fat embolism and intracranial hemorrhage. In the former there are no signs of increased intracranial pressure; the pupils are usually normal and the spinal fluid is free from blood. There is a free interval, however, between trauma and cerebral symptoms which of course is present in both conditions.

**Prophylaxis**—Proper splinting and avoidance of unnecessary transportation without complete immobilization of fractures are important. Anesthetics that increase or predispose to shock, such as ether or avertin, should be avoided. In osteotomies the saw should be used in preference to the chisel. Major orthopedic operations on the extremities are best done under a rubber constrictor.

**Treatment**—Adrenalin raises the blood pressure and aids the right heart to dislodge some of the fat from the capillaries of the lung. Ephedrine may be given for the same purpose. It has also been proposed to open and then ligate the main vein draining the injured bone should symptoms of fat embolism recur. No emulsifying agent given intravenously has been found to protect the experimental animal from fatal fat embolism.

#### AIR EMBOLISM

The entrance of air into the vascular system requires gaping of the injured vein and a marked negative sucking action toward the heart. These factors are present at the large veins of the neck and root of the arm (internal and external jugular, subclavian and axillary veins) that are fixed by fascial coverings and cannot readily collapse. The placental veins following childbirth are another source of air embolism. The emboli may contain amniotic fluid.<sup>1</sup> The pulmonary veins when surrounded by scar tissue

that prevents collapse are particularly predisposed to permit entrance and transport of air. The anterior bronchial veins empty into the pulmonary veins and from here into the left heart; the posterior bronchial veins empty through the azygos or the intercostal trunks into the right heart.

The capillaries of the lung are not permeable to air as they are to fat, but through an open foramen ovale air may pass from the right heart to the left. Should air however reach the arterial tree it can pass through the capillary bed into the venous system. This difference between the pulmonary and peripheral capillary beds may be best explained by the much greater pressure in the peripheral arterial circulation.

When air enters the right heart it is pressed in the shape of foam or large bubbles into the pulmonary artery; death occurs through asphyxia just as in thromboembolism should a large bubble completely occlude the artery or it may plug the smaller branches and it is usually assumed that when two thirds of the vascular bed is occluded asphyxia begins.

The surgical procedures that are most apt to be followed by the occurrence of air embolism are thyroidectomy, radical breast amputation, puncture of paranasal sinuses, injections of air into the bladder or into joints or tubal insufflation. Childbirth or operations on the pregnant uterus may produce an air embolism. Pleural puncture, pneumothorax or operations on the lung itself may produce an embolism of the peripheral arteries. The danger of air embolism from intravenous drip or injection treatment must be minimal as 5 to 10 cc. of air has been injected rapidly in man without producing clinical symptoms.<sup>13</sup>

**Symptomatology**—In the case of venous air embolism the characteristic hissing sound is heard almost immediately followed by a peculiar churning in the heart. The intensity of this second sound varies from one which is heard at considerable distance from the patient to one which is barely audible with the stethoscope. This is followed by dyspnea, cyanosis, a small rapid pulse and the feeling of tightness in the chest, all of which may quickly disappear or progress to unconsciousness and death. As in thromboembolism death may be in

stantaneous or may occur after several hours. In arterial embolism sudden pallor is characteristic, segments of the tongue or of the retina may become anemic. Blindness, dizziness and tonic and clonic convulsions signify the cerebral insult.

**Diagnosis**—The diagnosis is readily made if the hissing or churning sound of air is obvious. If this is not the case, vasomotor collapse or thromboembolism may give an identical picture. In gynecological or obstetrical cases large pockets of air may form between the uterus and the placenta or in the peritoneum following rupture of the uterus and may remain silent for hours or days before they are suddenly sucked up into the venous circulation. In cases of arterial embolism the visualization of air bubbles in the retina—should there be time and opportunity for ophthalmoscopic examination—makes the diagnosis certain. Petechial hemorrhages in the skin are also characteristic.

**Prophylaxis and Treatment**—Large veins in the neck should be handled with caution. Veins should preferably be ligated before section. Frequent sponging with moist compresses may diminish the danger of an air embolism. If a vein is opened and bubbles become visible at the site of injury, a finger or moist sponge should immediately occlude the opening. Once the air has entered the right heart, nothing can prevent the further course of events. A horizontal position may aid to keep the air bubble in the right ventricle, whereas a change to a semisitting position has been known to kill the patient instantly. [Bohn<sup>1</sup> reports a case of nearly fatal air embolism with misuse of a positive pressure apparatus for intravenous fluid administration. The patient recovered after aspiration of about 50 cc of blood stained froth from the left external jugular vein.—Ed.]

The prophylaxis and treatment of air embolism from the pulmonary veins is naturally different. Great care must be exerted in establishing an artificial pneumothorax in that the needle is in the free pleural cavity. In cutting or cauterizing lung tissue the use of positive pressure is advisable. The

patient's head should always be lowered so that in case an embolism occurs the air bubbles will not ascend into the cerebral vessels. Plugging of cerebral or coronary vessels with air is rapidly fatal. In both venous and arterial embolism prophylaxis is most important. The administration of 100 per cent oxygen may save life or minimize permanent damage by absorbing the nitrogen bubbles from the vascular tree.<sup>14</sup>

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## XI. THE LYMPHATIC SYSTEM

### DISEASES OF THE LYMPHATIC SYSTEM

The lymphatic system maintains the front line of defense against the invasion of the body by infection. As a consequence it is of peculiar surgical significance. Neglected in the past for the more conspicuous arterial and venous systems it has come to assume an importance commensurate with that of the two other great circulations. With the advent of ideas concerning cellular immunity the protective function of the flow of lymph through the lymph nodes has become more clear.

Absorption was solely a function of the lymphatic vessel. This was in the eighteenth century. The utilization by the body of water and minerals—a major part of the lymph problem—is constantly concerned in the modern management of surgical disease.

### ANATOMY AND PHYSIOLOGY

The lymphatic system consists of the *lymphatic vessels* and the *lymphoid organs*. The endothelium lined vessels originate blindly throughout the body (Fig 100 A) with the exception of the central nervous system, muscle bundles and the substance of the

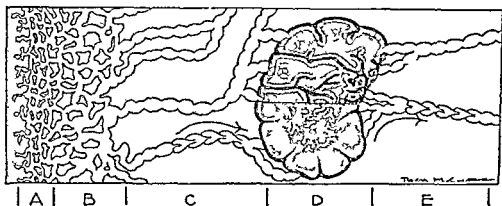


Fig 100—The structural basis of the lymphatic system (schematic diagram). A The irregular endothelial lymph capillaries. B The reticular network. C The afferent tubular lymphatics containing valves. D The lymph nodes present above the lymph sinuses and below the histological picture. E The efferent lymph vessels showing above the arrow, numerous valves.

Transport of the major portion of the fat absorbed from the intestine is another function of the lymphatic system. While this is perhaps of greater significance to metabolism and nutrition nevertheless it has as will be seen certain surgical implications. The mesenteric lymphatics, the arteries containing milk of Erasistratus were originally recognized in 1692 by the Italian anatomist Aselli because of this property.

The formation, flow and absorption of lymph are fundamental physiological problems. Nevertheless they and particularly their solutions have a direct bearing on surgical progress. John Hunter, British surgeon, anatomist, even maintained that ab-

sorption was solely a function of the lymphatic vessel. This was in the eighteenth century. The utilization by the body of water and minerals—a major part of the lymph problem—is constantly concerned in the modern management of surgical disease. The lymphatic system thus differs from the continuous closed blood vascular system in two significant respects: (1) It returns in a roundabout way a part of the tissue fluid

to the general circulation in the form of lymph and (2) this lymph passes through numerous lymph nodes interspaced along its course

parts involved. As a consequence it is of value to review at greater length the anatomy and physiology of the lymphatic system.

*Lymph* is the fluid which flows through the lymphatic vessels. It is derived from the tissue fluids. These originate from two chief sources. The greater part passes from the blood capillaries into the tissue spaces. This part is essentially a modified blood plasma. Another portion originates as a result of the metabolic processes within the tissue cells. Since tissue cells differ in structure and in function the composition of this portion of the tissue fluid varies. The mechanism of formation of the tissue fluid after extensive researches and much controversy is not yet clear. Likewise the process of its absorption into the lymphatics to form the lymph is an unsolved fundamental problem.

An analysis of lymph reveals that there are but few essential differences between it and blood plasma. It has less protein. Since it contains less fibrinogen than the blood plasma it coagulates more slowly. On the other hand under inflammatory conditions it becomes rich in proteins and coagulates more readily. The products of tissue metabolism may render it toxic. Its quantitative composition varies greatly depending on the activity of the part from which it is collected. It is greatly altered under certain pathologic conditions. In certain forms of edema it is poorer in solids.

*Chyle* is a milky admixture of lymph and emulsified fat formed in the blindly ending lacteals in the centers of the intestinal villi during digestion. During starvation the distensible lacteals are collapsed and the decreased intestinal lymph is then quite similar to other lymph.

*Lymphatic vessels* are found with certain exceptions some of which have been noted wherever there are blood capillaries. However there also exist throughout the body irregular slit like spaces and cavities within the connective tissues. These *tissue spaces* are not a part of the lymphatic system although they contain a tissue fluid which has often been called lymph. Similar to these tissue spaces but on a larger scale are the *synovial cavities* and the *meningeal spaces*. In this group are also the mesothelium lined

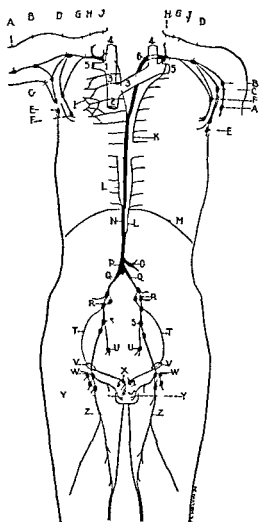


Fig 101—Diagram of the lymphatic system (adapted from Cunningham) showing the main vessels. A Brachial nodes B lateral axillary nodes C central axillary nodes D infraclavicular nodes E subscapular nodes F pectoral nodes G subclavian trunk H left and right jugular trunk I anastomoses J bronchomediastinal trunk K ascending trunk L descending trunk M diaphragm N thoracic duct O intestinal trunk P cisterna chyli Q left and right lumbar trunk R lumbar nodes S lacteal nodes T spermathecal vessels U epigastric nodes V inguinal ring W subinguinal nodes X testes Y perineal and scrotal vessels Z vessels from lower extremities 1 right lymphatic duct 2 superior vena cava 3 left and right innominate veins 4 left and right internal jugular veins 5 left and right subclavian veins 6 thoracic duct

An understanding of the nature of lymphatic disease or for that matter of other surgical diseases is based on an adequate concept of the structure and function of the



*serous cavities*—peritoneal, pleural and pericardial and the tunica vaginalis etc. The term lymphatic should be reserved for the endothelium lined channels.

The *lymph capillaries* (Fig 100 A) begin blindly as irregular thin walled tubes. They branch and anastomose freely forming a closed network. This *reticular network* (Fig 100 B) lies close to the smaller blood capillary plexus however deeper from the skin surface. *Tubular lymphatics* (Fig 100 C) emerge from this network and pass to the lymph nodes and beyond. These are beaded in appearance owing to their numerous valves. Smooth muscle is found in their walls. The larger *lymphatic vessels* unite and become progressively thicker walled until they form the thoracic duct (Fig 101 N). The wall of the thoracic duct is similar to that of a great vein with the exception of a thicker more muscular media.

The *lymphoid organs* are intimately connected with the lymphatic vessels. Essentially they consist of a collection of lymphoid cells living in a meshwork of reticular fibers. Most important are the *lymph nodes* (lymphoglandulae) commonly known as lymph glands. They 'filter the lymph' which slowly flows through their network of *lymph sinuses* (Fig 100 D). These sinuses closely surround the *lymphoid nodules*.

Substantially all of the lymph passes through one or more lymph nodes on its way to the veins. The significance of this fact in the resistance of the body to infection may be readily demonstrated. Tubercle bacilli injected into the groin of a guinea pig may be recovered in the iliac lymph nodes.

The lymph nodes have other functions. They manufacture lymphocytes principally in the lighter staining germinal centers of the lymphoid nodules (Fig 100 D) where mitoses are frequent. They remove foreign particles for example inhaled soot in the lungs. They form phagocytic cells which consume bacteria. The lymphocytes however, are not phagocytic. It is an open question whether they produce immune bodies.

The flow of chyle may be taken as an example of the pathway followed by lymph in reaching the general circulation. From the lacteals it passes through a reticular network in the intestinal wall. In the regions

where Peyer's patches (noduli aggregati) or solitary nodules are present the chyle flows through a fine meshed network closely surrounding the lymphoid nodules. It leaves through stems at the mesenteric attachment to enter small lymph nodes lying close to the intestine and between the two peritoneal layers of the mesentery. It passes usually through three series of mesenteric lymph nodes of increasing size. The first lie about the origin of the superior mesenteric artery. There are from 100 to 200 mesenteric nodes. The protection thus afforded against infection from the intestine is evident. The vessels connecting the mesenteric lymph nodes contain valves.

Chyle then leaves the mesenteric nodes to flow through the celiac nodes. The efferents from this group of about twenty large retroperitoneal nodes may enter the *cisterna chyli* (Fig 101 P) directly, join the left lumbar trunk (Fig 101 Q) or form a separate *truncus intestinalis* (Fig 101 O) which empties into the cisterna. From there chyle is transported by the thoracic duct to the left subclavian vein (Fig 101). The flow of chyle may be readily demonstrated experimentally.

The flow of lymph from other parts of the body has as characteristic a course. In a similar manner it passes through definite groups of lymph nodes on its way to the veins. Since lymph nodes are the site of deposit of malignant metastases and since pathogenic organisms are carried to them, the area drained by any given group is of significance. These facts and instructive diagrams may be found in any standard text book of anatomy.

**The Flow of Lymph**—The flow of lymph corresponds in part to the more rapid circulation of the venous blood. It becomes of significance in four conditions. (1) It plays a part in maintaining the normal fullness of the tissues. This the *tissue turgor* is also dependent on the blood capillary circulation as well as the state of the tissue fluids. This tissue turgor is notably decreased in infants under certain pathologic conditions. It is obviously increased in lymphoedema. (2) Pathogenic organisms originating in an infected finger in the intestine or in the tonsils are disseminated by the flow of lymph. (3) Malignant cells, some destined

to lodge and form distant metastases are carried along by the lymph current (4) Waste products from the tissues and nutrient substances such as chyle are also transported As a consequence certain features of the mechanics of lymph flow may be briefly considered

The *vis a tergo* the propelling force is substantially a difference in pressure between the two ends of the lymphatic system In the lymph capillaries the pressure is increased Where the main trunks open into the great veins of the neck the pressure is low and may even be negative It is difficult to estimate the lymph capillary pressure Actual measurements are not available The actual effect of the tissue fluids and of the tissue turgor on the lymph capillary pressure is not clear The pressure in the adjacent blood capillaries varies up to 92 mm of mercury It seems reasonable to presume that the lymph capillary pressure depends on the pressure within the blood vessels and consequently on the force of the cardiac systole The heart beat thus supplies some of the energy for the slower circulation of the lymph

*Necessary factors* also play a part Smooth muscle is found in the walls of the tubular lymphatics An unusual amount occurs in the thoracic duct Numerous closely spaced valves exist along the lymphatic vessels and particularly at the entrance of the main trunks into the cervical veins The pumping action of the intestinal villi aids in the propulsion of chyle Muscular activity and the respiratory cycle also play their part

Compared to the venous circulation the flow of lymph is slow Its velocity although variable has been estimated as 4 mm a second The amount of lymph flowing through the thoracic duct as estimated by measuring the amount coming from a lymph fistula is from 50 to 120 cc per hour

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#### THE LYMPHATIC VESSELS

##### TRAUMA

All wounds open lymphatic vessels The exuding lymph with its contained cells mostly lymphocytes normally contributes to the healing process The serum collecting in a wound is largely lymph This coagulates more slowly than the blood and seals the open ends of the lymphatic network Healing is as a rule prompt and uneventful Subsequent wound secretion is ordinarily absorbed and carried away by the surrounding blood and lymph capillaries If it accumulates evacuation may be necessary

Wounds in the axilla or groin may injure large lymphatic trunks This may occur for example in an extensive biopsy to remove adherent inguinal nodes The discharge of considerable clear fluid *lymphorrhea* ensues The wound may be slow in healing but eventually closes Pressure or cauterization of the wound with silver nitrate may be employed to hasten closure

Injury to the thoracic duct is of major significance It may follow severe trauma However it occurs most frequently during operations at the left base of the neck It has happened for example during the radical excision of tuberculous cervical lymph nodes Since the curved terminal portion of the thoracic duct may extend as high as 5 cm above the manubrium its presence should not be forgotten during extensive dissection in this region

Injury to the thoracic duct is recognized by the presence of chyle in the wound This escapes synchronously with expiration Two courses are then open If possible a lateral anastomosis should be attempted Failing in this both ends of the duct should be ligated The collateral circulation is adequate (Fig 101 I and J) to return the chyle to the venous circulation Experimentally continuity of the thoracic duct is not necessary to life Following ligation a collateral circulation through the right lymphatic duct develops Other lymphaticovenous anastomoses are even recognized and described

If the injury is unrecognized it makes it

self known in the following manner. The lower portion of the wound swells. Spontaneously or after the insertion of a hemostat there occurs a gush of milky fluid and a continuous *chylothorax* then ensues. This is threatening since liters of fluid with contained minerals and fats are thus lost. Rapid emaciation is noted and the general appearance of dehydration and starvation. *Replacement therapy* may be necessary. The resulting *lymph fistula* may be treated by cauterization or by firm gauze packing. If these fail dissection and ligation of the injured duct may be necessary. The mortality is reported as being between 5 and 10 per cent. Injury to the right lymphatic duct (Fig 101 I) is not so serious.

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#### LYMPH STASIS

Obstruction to the flow of lymph may involve any of the successive parts of the lymphatic system. For example recurrent *eczema* involving the reticular lymphatics of the skin may result in their partial or complete obliteration. The collection and flow of lymph are thus hindered. The subcutaneous tissues become thickened, sodden and firm and *lymphedema* is the eventual outcome. This consists of three components. The tissue fluids are not properly absorbed. As a consequence they increase and (a) *edema* results. Since the outflow of lymph is impeded the uninvolved lymphatics dilate with fluid and (b) *lymphangectasis* ensues. As the process continues there is added (c) a *cellular reaction* and eventually *fibrosis*.

Lymphedema also results from other causes particularly thrombophlebitis of the axillary, brachial or iliac femoral veins. The inflammation spreads to the surrounding perivascular lymphatics and lymphangitis develops. Some of the lymphatics become sclerosed. This interferes with the return flow of lymph from the extremity. Cancer of the breast may so invade the axillary lymphatics as actually to interfere with the return flow of lymph from the arm. At first the affected arm is swollen and a pitting edema is present. It then becomes

tight, firm to pressure and uncomfortable. Finer movements of the hands are lost. As the lymphatic block becomes more complete the arm becomes progressively pale, painful and useless. Elephantiasis may subsequently develop.

*Phlegmasia alba dolens* literally a painful white inflammation is commonly called milk leg. The name was given before the true nature of the process was understood. It is an example of the effect of thrombophlebitis accompanied by blockade of the principal lymphatic trunks. It usually appears a week or ten days after delivery as thrombophlebitis of the iliac femoral vein. The leg becomes swollen and firm. However instead of appearing dusky from the inflammation and venous stasis it is pale, tense and shiny. This effect is doubtless due to the associated lymph stasis. Usually the swelling subsides within two weeks. As a rule the venous circulation is restored in a remarkable manner. The lymph stasis however is slower in receding. A variable resultant edema may persist throughout life owing to some fundamental disturbance of lymph formation and flow.

It may be necessary to differentiate *hereditary edema* from the various lymphedemas. Called also *Milroy's disease* this was described by Milroy in 1892. The principal features are the familial incidence and the circumscribed edema usually of the legs. There is no known cause, local or general. There is no evidence of lymphatic obstruction. The affected limb is painless, pits on pressure and is firmer than in ordinary edema. Acute exacerbations are recognized and have been regarded as the result of a vascular neurosis.

The familial incidence, the absence of all ordinary causes of edema, the continued chronicity and the unimpaired general health are diagnostic aids. *Treatment* consists in early and persistent bandaging together with measures to control the edema. If allowed to go untreated the enlargement may simulate elephantiasis. Lymphangioplasty is of no avail.

*Treatment*—The treatment of lymph edema depends on the stage at which the disease is encountered. Early mild cases subsequent to the lymphangitis associated with thrombophlebitis in the extremities

respond to rest elevation massage and support by bandaging. It is important in other cases to recognize the underlying cause of the lymph stasis and to manage it properly. In moderately advanced cases the basal metabolism should be determined. Particularly if it is low the administration of desiccated thyroid may prove of value. The results from this are occasionally striking.

Failure of absorption of the edema fluid is essentially a tissue problem since the kidneys are usually normal and function well. As a consequence administration of the newer mercurial diuretics may be considered. These act in part at least on the extrarenal tissues increasing their permeability. As a result of their action the body rids itself in the urine of a striking amount

If the various forms of palliative treatment fail *operative treatment* may be undertaken. There are two main operative procedures for consideration. *Lymphangioplasty* was introduced by Handley in 1908. Its principle was to furnish a new capillary pathway for the centripetal passage of the obstructed lymph. This was accomplished by inserting long strands of sterile tubular woven silk into the subcutaneous tissues from the wrist or ankle to the axilla or groin. This was done through multiple openings and the free ends were buried before the skin was closed. The silk thus acted as a new lymphatic conduit. Successes have been reported but experimental evidence shows that the beneficial effects are temporary. The threads excite a cellular reaction and

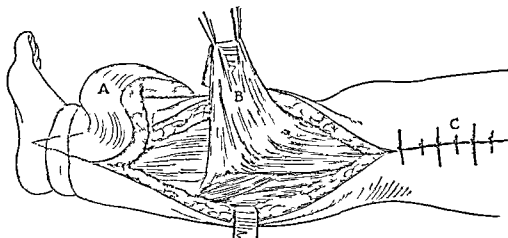


Fig 102—The Kondoleon operation for elephantiasis. A First removal of a strip of the thickened skin. B Water removal of the thickened deep fascia, leaving the muscles. C closure of the wound.

of salty water. Salty water with ammonium chloride usually depletes greatly the fluid in the water-logged extremity. The results are best when accompanied by other suitable measures. The data obtained in studying these cases would seem to indicate an increase also in the permeability of the blood capillaries, since the outflow of lymph through the lymphatics is mechanically hindered.

In advanced cases *decubitus* may develop and require attention. *Varicose ulcer* may occur in patients with varicose veins and recurrent thrombophlebitis. It improves as the lymphedema receives appropriate treatment. *Vaccine therapy* as well as medication with sulfa drugs has been used to combat the recurring lymphangitis.

In about three weeks fibrosis of the new channel has resulted so that the thread is isolated and surrounded by scar. The thread is later actually disintegrated. Handley frankly states ten years later: "In my own hands this plan has not been permanently successful and I am unable to recommend it."

The *Kondoleon operation* (Fig 102) was described by a Greek surgeon in 1912. It has been popularized in England by Rogers and in America by Sistrunk. Its principle is twofold. It plastically reduces the size of the enlarged limb by removing large strips of skin and subcutaneous tissue and, more important, it permits drainage of the obstructed superficial into the open deep lymphatics. This is effected by removing

widely the scarred and thickened aponeurosis. It will be further considered in the treatment of *elephantiasis*.

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### THORACIC DUCT OBSTRUCTION

Obstruction to the lymphatic vessels and to the larger lymphatic trunks results in lymph stasis and lymphangiectases. The lymph stasis is manifested particularly as edema owing to the inadequate absorption of the tissue fluids. The lymphangiectases become evident in an added manner. On the skin of the involved extremity appear small blebs visible with a hand lens and containing a clear fluid. These are to be noted particularly where there is a dermatitis where the skin has been abraded or in the region of an ulcer. The clear fluid is lymph and in this manner the congestion is partially relieved.

When the thoracic duct is obstructed the same phenomenon ensues. Then however chyle exudes into the peritoneal cavity into the pleural cavity or even into the kidney pelvis or bladder. In this manner occur *chyloous ascites*, *chylothorax* and *chyluria*.

A number of conditions have been reported as causing obstruction of the thoracic duct. These may be (a) enlarged mediastinal lymph nodes, the result of tuberculosis or of the deposits of carcinoma or of Hodgkin's disease; (b) mediastinal tumors; (c) valvular incompetence with subsequent enlargement of the left atrium and pressure; (d) filarial disease due to the presence of the parent worms within the duct; (e) bilharzias due to the presence of the blood fluke *Bilharzia henatobia* in the duct; (f) stenoses such as occur following the invasion of the duct walls by tuberculosis or carcinoma or as following scarring; (g) cardiac hypertrophy acting by direct pressure; (h) pancreatic neoplasms described by Agnew; (i) intrathoracic goiter reported by Schultz; (j) thrombosis of the left subclavian vein at the usual opening of the thoracic duct; (k) aneurysm of the aortic arch by pinning the duct against the ver-

tebral bodies. (l) malignant disease of the pleura noted by Sahli; (m) surgical ligation as discussed above.

Subsequent to obstruction of the thoracic duct the lymph pressure increases and the lymphatics dilate. A collateral circulation is eventually established through the bronchomediastinal trunk through other thoracic lymphatics or even through capillary anastomoses into the right lymphatic duct. Other lymphaticovenous anastomoses known but not generally recognized may return the obstructed chyle to the veins. Nevertheless leakage occurs and the external chyle may even rupture. Chyle may also pass into the peritoneal cavity from the induced lymphangiectases by the mechanism of *diapedesis* according to Sahli.

Chyloous ascites may also occur subsequent to direct trauma with rupture of the external chyle, the thoracic duct or any of the larger lymphatic vessels. Carcinomatous metastases filling the mesenteric lymph nodes may so obstruct and dilate the tributary lymphatics as to cause chyle to appear in the peritoneal fluid. *Chylothorax* may likewise ensue after severe injury to the chest.

The treatment is by paracentesis and it may be necessary to repeat this several times. The fundamental cause should be sought and if found should receive due consideration.

Chyle may enter the urine from the kidney pelvis or from the urinary bladder. The simultaneous rupture of blood vessels and of dilated varicose lymphatics has been described. This results in both *chyluria* and *hematuria*. The pressure of a tuberculous lymph node on the thoracic duct with the subsequent appearance of chyle in the pelvis of both kidneys has been reported. The lymph stasis involved the lumbar trunks (Fig. 101 Q), the lumbar nodes and their tributaries from the kidney. Havelburg has proved that chyle may escape into the urinary bladder.

### ELEPHANTIASIS

Elephantiasis is a late result of chronic persistent lymphatic obstruction. In addition due to increased resistance a recurrent lymphangitis has usually been superimposed on the resultant lymphedema. It in-

febrile attacks similar to those of patients with elephantiasis. Streptococci were cultured from the tissue fluid always at the beginning of an attack.

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### LYMPHANGITIS

Lymphangitis is an inflammation of the lymphatic vessels. It is due, as a rule, to pathogenic cocci, although various other organisms may act as causal agents. Like other forms of inflammation it may be acute, subacute or chronic. Recurrent varieties are well recognized. Since the lymphatic vessels exist in two forms there are two corresponding varieties of lymphatic inflammation. (1) *Reticular or capillary lymphangitis* may occur anywhere in the skin of the body. (2) *tubular lymphangitis* is most commonly observed in the skin of the extremities. But little is known concerning lymphangitis as it involves the deep lymphatics. It would seem to be more significant than is recognized and consequently, should merit further investigation.

**Reticular Lymphangitis.**—Acute reticular lymphangitis commonly due to streptococcal infection involves the multiple plexiform vessels in which the lymph is collected (Fig. 100, A and B). In its less severe forms it is usually seen in wound infections as a spreading pink to deep red blush surrounding the area of trauma. Through this portal of entry the invading organisms have entered the lymphatics of the skin and have set up the consequent process of acute inflammation. Varying degrees are recognized, the most severe forms being seen in erysipelas. It is not commonly recognized that a great part of this disease is a progressive inflammatory involvement of the capillary lymphatics of the skin.

The causative pathogenic organisms are usually streptococci. Other bacteria however, such as the staphylococci, the anthrax bacillus or the gonococcus may induce the characteristic changes. An intense hyper-

emia occurs and the area becomes red, tense and swollen. The lymphatic vessels become distended and filled with clotted lymph. Within and about them are many leukocytes. Endothelial desquamation ensues. The inflammation extends in varying degrees to the surrounding tissues. Perilymphangitis or even cellulitis may ensue and in the latter instance suppuration may follow.

The clinical course usually begins with a wound although this may be quite insignificant. It may be superimposed on a chronic eczema or may arise at the margin of a long standing ulcer. The onset is usually acute as the infection invades the networks of vessels. Often there is an early chill and the temperature rises rather abruptly to 102° or 103° F. The pulse rate increases, malaise is noted and general symptoms such as vomiting or headache may ensue. The area is usually quite tender and may be painful. In a day or so depending on the type and severity of the primary infection irregular red streaks may be seen (Figs. 103 and 104) extending from the diffuse red area up the extremity. This is due to the subsequent tubular lymphangitis. The regional lymph nodes become swollen and tender. Along the course of the tubular lymphangitis may appear a diffuse red area, a patchy reticular lymphangitis. The milder infections usually resolve particularly after appropriate treatment. The severer forms may result in necrosis in necrotizing ulcers or in cellulitis with suppuration. If the lymph node barrier proves inadequate the rapidly progressive infection may result in septicemia.

The portal of entry is not always as obvious as in the little finger shown in figure 103. The prick of a contaminated needle has in many cases resulted in rapidly evolving reticular lymphangitis, tubular lymphangitis, acute lymphadenitis, septicemia and death. This is the popularly termed 'blood poisoning'. However it is the failure of the lymphatic defense which is of primary significance and it might as reasonably be termed 'lymphatic inadequacy'.

Treatment will be discussed later after a consideration of the closely associated tubular lymphangitis.

**Tubular Lymphangitis.**—Acute tubular lymphangitis is an acute inflammation of

volves particularly the legs but may occur in the arms, scrotum, vulva or breasts. There are varying degrees. In well developed instances the parts are truly elephantine. The skin is enormously thickened and thrown into folds and the epidermis often presents numerous warty projections. There is a firm edema of the less involved parts. The dermis is greatly thickened and fibrosed and the subcutaneous fat is excessively increased. It is scarred and its deeper portions are water logged. Near the deep fascia it contains much free watery lymph. The deep fascia is surprisingly thickened its outer surface being rough and papillary and attached to the fibrous trabeculae separating the edematous fat lobules. Its inner surface is smooth and appears normal as do also the underlying muscles.

Various forms of elephantiasis are described. Galen recognized the disease as occurring along the southern Mediterranean coast hence the name of the tropical form *elephantiasis arabum* which is due to *filariasis*. There are several species of the small causative threadworm. The common one *Wuchereria (Filaria) bancrofti* is from 2 to 4 inches in length and about the size of ordinary catgut. The worms are bisexual the males being the smaller. When mature they breed and later the females produce living embryos. These enter the blood stream where they may be found microscopically wriggling among the blood corpuscles. These minute embryos living in the blood are called *Filaria sanguinis hominis*. The adult worms live in the lymphatic system. They are found in the various lymphatic vessels and in the sinuses of the lymph nodes. By obstructing and damaging the lymph channels they set up a variety of pathologic changes. Among the diseases due to filariasis are lymphangitis, lymphadenitis, hydrocele, lymph scrotum, chylous ascites, chylous cysts and elephantiasis.

Filariasis is transmitted by the bite of the mosquito *Culex fatigans*. Other mosquitoes however may act as the intermediate host. The blood borne embryos leave the stomach and metamorphose within the muscles of the insect carrier. This takes about twelve days (Low). The larvae then migrate to the head and pass out along the bill of the mosquito. They enter the skin through the

puncture wound or may even penetrate the unbroken epidermis. On reaching the lymphatics they complete their development and become adult worms.

**Treatment**—The treatment of filariasis is essentially prophylaxis since proposed treatments of the established disease are unsatisfactory. Antimony salts have been given intravenously but a prolonged course of the highly toxic drug seems necessary. *Surgical treatment* has been applied to three of the manifestations. *Amputation* of the often huge lymph scrotum has proved satisfactory. In skilled hands it is a safe operation. *Excision* of the boggy mass of inguinal glands is unsatisfactory. This mass may be mistaken for hernia. It contains enormously dilated lymphatics and consequently varies in size and elasticity. For the elephantiasis the *Kondoleon operation* (Fig. 102) has proved of benefit. It removes at least a great part of the unwieldy mass. The establishment of secondary connections between the superficial and the deep lymphatics is of manifest value. This is a challenging and fundamental surgical problem. It is obvious that the main trunks at the axilla or groin should be patent to obtain the best results. Since in filarial elephantiasis the fundamental cause remains the final result is open to question. *Handley's lymphangioplasty* is of little avail.

Elephantiasis is not always a tropical disease nor is it always filarial. It may be a sequel to any persistent lymphedema and particularly to those complicated by neglect a dirty skin and consequent recurrent visitations of reticular lymphangitis. For example it has followed carcinomatous blockade of the axillary lymphatics, radical breast amputations, extensive tuberculous invasion of the lymphatics of the leg, ring ulcer of the leg and recurrent attacks of erysipelas (reticular lymphangitis). The *Kondoleon operation* has proved of greater value in certain of these nonfilarial forms and good results are still being reported.

*Experimental elephantiasis* has been produced in dogs by Honans, Drinker and Fiehl who injected a 0.5 per cent solution of quinine iodide subcutaneously with a suspension of silica dust into the peripheral lymphatics. The injury of the lymphatic vessels and the nodes to which they were tributary. The injury was sufficient to result in fibrosis and gradual obliteration. The dogs manifested subsequent recurrent

febrile attacks similar to those of patients with elephantiasis. Streptococci were cultured from the tissue fluid always at the beginning of an attack.

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- Homans J., Drinker C. J. and Field M. Elephantiasis and the Clinical Implications of Its Experimental Reproduction in Animals. *Ann. Surg.* 100: 812, 1934.
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### LYMPHANGITIS

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Treatment will be discussed later after a consideration of the closely associated tubular lymphangitis.

**Tubular Lymphangitis.**—Acute tubular lymphangitis is an acute inflammation of



the tubular lymphatic vessels commonly called lymphangitis. It is frequently seen in the dispensary. The patient presents a wound of the hand which has become infected, a blister of the foot which has had improper treatment or an infected ingrowing toe nail (Fig 104). The hand or foot is locally feverish, red and swollen from the infection and the associated capillary lymphangitis. It is often tender. Extending up the arm or leg as the case may be are irregular red streaks due to acute inflammation of the walls of the tubular lymphatics (Figs 103 and 104). The regional lymph nodes are swollen and tender.

The *pathogenic organisms* are frequently streptococci. Others however may set up the initiating wound infection with its surrounding reticular lymphangitis. The invaded tubular lymphatics are surrounded by a region of hyperemia. Exudation occurs and the vessels become filled with coagulated lymph, desquamated endothelial cells and leukocytes. Progress along the lymphatic trunks is variable in some cases being quite rapid. It may extend from the finger to the armpit in from twelve to twenty-four hours depending on the type and severity of the initial infection.

The *clinical manifestations* are those of varying degrees of infection with the superimposed red streaks winding up the extremity. This streaking is variable. It usually extends through the first defense nodes but may go around them. It is ordinarily seen to end in the nodes of the axilla or groin. However in some instances it doubtless involves the deeper and invisible vessels extending centrally from the axillary or inguinal nodes which are enlarged, palpable and tender.

The majority of the infections subside rapidly under adequate treatment. Often in four or five days after the onset no residual evidence is seen. On the other hand certain infections are rapidly and progressively fatal even within forty-eight hours after the initial infection. This tragic outcome may be due to the virulence of the infecting streptococcus, the lowered resistance of the patient, the inadequacy of the lymphatic defense barrier or even to injudicious treatment. The fatal result in these cases is due to *septicemia* as may be shown by blood cultures. Further evidence is later found in

the microscopic demonstration of widely disseminated areas of infection.

In other cases local abscesses may form along the tubular lymphatics. The perilymphangitis may extend and diffuse cellulitis sometimes develops which may suppurate. Infection of the hand with lymphangitis and its sequelae may lead to a series of disabling complications unless properly managed.

The *treatment of lymphangitis* comprises prophylaxis, management of the acute infection and recognition of and attention to the complications. Prevention is perhaps best accomplished by rigid surgical care of wounds particularly those of the hands and feet. Where streptococci are known to be present this attention should be scrupulous. Wounds of the hands of manual laborers should receive early and judicious treatment. The skin of the extremity with lymphedema or elephantiasis should be kept clean to prevent recurring attacks of reticular lymphangitis.

The *usual management* of the acute infection is by the institution of rest and the application of hot moist dressings. Use of sulfur drugs is of particular value in those forms due to streptococci. Their effects are sometimes striking. Rest local and general is obviously of value. Hospitalization with the institution of complete bed rest and care often rapidly terminates a severe infection. In case of tubular lymphangitis of the extremities the dressings should envelop the entire arm or leg and cover the axilla or groin. Since local dehydration seems of value the dressings may be kept moist with a saturated solution of magnesium sulfate or with mixtures containing glycerin. Antiseptic solutions have no particular value and may even prove harmful. As the infection subsides the magnesium sulfate solution may be replaced by boric acid or salt solution.

If an abscess develops in the initial wound it should be opened and drained but this is not ordinarily necessary. The septic hand requires special and skilled care. When cellulitis with definite suppuration occurs it should be drained. Incision of the acute tubular lymphangitis should never be done owing to the danger of disseminating the infection. Local abscesses and abscesses within

the regional glands may require incision and drainage. Hilton's method should be employed. The general condition of the patient is aided by an increased fluid intake. If fluids are not readily tolerated by mouth they are best administered by hypodermoclyses of Ringer's solution.

**Chronic Lymphangitis**—Chronic lymphangitis may follow an acute attack which has not received adequate treatment. It may be maintained in the lymphatics peripheral to a blocking subsequent to previous acute lymphangitis. A recurrent form manifesting itself as periodic attacks of reticular lymphangitis frequently occurs in the skin of extremities with lymphedema or elephantiasis. A specific portal of entry is difficult to determine. The lymph stasis present and an unclean skin are predisposing factors. This form has previously been described. The more common forms of chronic lymphangitis are cancerous, tuberculous, syphilitic and filarial. The sporotrichotic variety is rare. One of the principal effects is an interference with the normal flow of lymph from the involved part due to the progressive thickening, fibrosis and eventual blocking of the lymphatic vessels. The usual results of this have been previously considered.

**Tuberculous lymphangitis** is rare. With out much doubt the tubercle bacillus is carried about the body and particularly to the lymph nodes by means of the lymphatic vessels, yet the vessels themselves are seldom involved. This would argue for the effectiveness of the lymphatic endothelium.

Occasionally it is seen in the hand or arm as a sequel to a primary focus in the hand. This source of continued infection, the *anatomical tubercle*, may give rise to ascending tuberculous lymphangitis. The lymphatics become thickened and nodular and are palpable. They may become cord like. The nodules are at first firm and solid. Later they soften, form abscesses and break down forming ulcers. The epitrochlear and the axillary glands are invaded. A similar condition occurs in the mesenteric lymphatics and in the mesenteric lymph nodes from intestinal tuberculosis.

The treatment is general and local. The initial lesion should be excised if possible to remove the source of the infection. It may be necessary to curette or even excise

the broken down areas along the course of the lymphatic vessels. The involved lymph nodes may require excision if other measures fail. X ray therapy is of value.

**Sporotrichosis**, a rare mycotic disease due to infection with the various species of the *Sporotrichum*, presents an unusual form of chronic lymphangitis. (See section on Sporotrichosis.)

**Chronic non granulomatous lymphangitis** has been described. It is difficult to regard this as a clinical entity. It is not easy to distinguish it from the tuberculous form. However no specific causative organism has been found. It behaves much as tuberculous lymphangitis, although the tubercle bacillus is not demonstrable. Treatment is directed at the initial lesion and at the enlarged regional lymph nodes which should be excised. The lymphangitis needs no other treatment.

**Syphilitic lymphangitis** is occasionally seen on the dorsum of the penis subsequent to the primary infection. The lymphatic vessels become firm, cord like and readily palpable. There may be an accompanying lymphedema of the foreskin. The treatment consists of an attack on the causative disease.

**Cancerous lymphangitis** is an obliterating form due to the plugging of the lymphatics with metastasizing malignant cells. There may be demonstrated microscopically, a surrounding inflammatory reaction and fibrosis.

**Filarial lymphangitis**, one of the many effects of the invasion of the body by *Wuchereria (Filaria) bancrofti* has been discussed in a preceding section.

#### LIMPHANGIOMATOSIS

**Lymphangiectases** or varicose lymphatics are dilatations of lymphatic vessels. They are analogous to hemangiectases which occur in the peripheral blood vessels and contain lymph instead of blood. *Congenital forms* are recognized and result from some disturbance of the normal development of the primitive lymphatic plexus. However they are most commonly encountered as one of the sequelae of lymph stasis and have been discussed under that heading.

Lymphangiectases may be demonstrated in the mesenteric lymphatics subsequent to extensive invasion and replacement of the

mesenteric and celiac lymph nodes by metastatic carcinoma. When the abdomen is opened the distended lymphatics are sometimes quite evident under the serosa of the intestine. The beaded thin walled vessels are readily demonstrable in the mesenteries and there is often an associated chylous ascites.

Treatment consists principally in considering the cause of the lymph stasis. In local forms not due to obstruction excision may be considered. For these however radium is of particular value.

The transition from lymphangiectases to true tumors of the lymphatic vessels is gradual there being no sharp dividing line. As a consequence considerable controversy has arisen with resultant confusion in the terminology.

### LYMPHANGIOMA

Lymphangiomas are true tumors of the lymphatic vessels. They may result from increased proliferation of the vessels to form a palpable snarl or proliferative changes may occur in their walls resulting in tumor formation. Cavernous dilatations are occasionally seen without evidence of previous obstruction. The endothelium which lines the vessels may give rise to endotheliomas. They may be congenital or acquired. They will be considered in four groups: *simple cavernous cystic* and *endotheliomatous*.

The lymphatic nevus is the simplest lymphangioma. It is usually seen in the skin although it occurs elsewhere. It may be colorless or faintly pink and barely palpable or slightly elevated. It is difficult to distinguish it on a rigid pathologic basis from a lymphangiectasis. Criteria which have been used are the evidence of proliferative changes, the connections with the surrounding lymphatic vessels and the evidence of a causal lymph stasis.

The hypertrophic form *lymphangioma hypertrophicum* is more definitely a tumor. It is usually congenital and, as a rule, is located in the skin. It may be flattened, protuberant or even papillary. It is definitely palpable. Although usually symptomless, rupture of the superficial vessels results in *lymphorrhea*. Microscopically the vessel walls are thickened, the endothelium is tall and the lumina are small. The proliferating ves-

sels are surrounded by fibrous connective tissue.

**Treatment**—Radium is of definite value in the treatment of the simpler forms of lymphangioma. If it is unsuccessful or in the papillary forms excision may be indicated.

**Cavernous lymphangioma** forms a definite tumor on the head or neck, about the genitalia or in the mesentery. It may be quite large. The lymphatic vessels lose their usual tubular form and become greatly dilated and saccular. The tumor is usually multilocular and the cavities are irregular. Their shape depends on the varying pressure of the surrounding structures. Aspiration yields lymph. The endothelial lining of the cavities is sometimes thickened. In other instances it is lacking in places owing to pressure, cyst formation and distention. Between the sacculations the connective tissue septa contain lymphocytes, elastic fibers and often smooth muscle.

**Etiology**—The etiology is obscure. The form occurring in the neck, *true cystic hygroma*, may originate from faulty metamorphosis of the primitive cervical lymph sacs. A developmental origin appears most likely although obstruction has been considered.

Disfiguring congenital enlargements of the tongue, face and hands are described. *Macroglossia* is a congenital enlargement of the anterior part of the tongue due to cavernous lymphangioma. The tongue may protrude far from the mouth as in Da Costa's case. It may interfere with breathing or eating. In *macrocheilia* the lips are enlarged by the lymphangioma which may also invade the cheek. *Macrocheiria* results from lymphangioma of the dorsum of the hand. Cavernous lymphangioma also occurs in the mesentery. Since this form contains chyle it has become known as a *chylangioma*.

**Treatment**—The treatment is by radium or excision. Radium may be used preliminary to surgical removal. Subsequent plastic repair may prove necessary.

The cavities of a lymphangioma may undergo cystic distention in which instance large cystic tumors develop. These occur in the neck as *cystic hygroma* (*hygroma colli cysticum congenitum*). (See section on Cystic Hygroma.)

**Endothelioma**.—An endothelioma is a

neoplasm arising from the endothelium lining the lymphatic vessels. Even in certain tumors of considerable size it is readily possible to trace the origin of the endothelial cells. On the other hand this is often difficult and for that reason uncertainty and consequent controversy have arisen as to the true nature of these tumors. The microscopic picture is variable. Hence endotheliomas have been regarded by some as forms of carcinoma and by others as sarcomatous. This doubt is reflected in the older terminology in the designation *sarcoma carcinomatodes*. Since endotheliomas also arise from the endothelial lining of the blood vessels the lymphatic form is specifically defined as *lymphangioendothelioma*. One form arises within the perivascular lymphatic vessels. This has been widely designated *perithelioma*. Though its origin is not likely within the lymphatic endothelium it is difficult to separate it on rigid pathologic criteria from the *hemangioendotheliomas*.

Clinically lymphatic forms of endothelioma occur offtest in the skin occasionally in that of the face as firm discrete slowly growing non adherent tumors. The overlying skin is uninvolved. They are observed at all ages. They are moderately invasive and later adherence and even ulceration may ensue. Metastases are infrequent. Peritheliomas are found in mixed tumors of the parotid and in tumors of the earrotid body. *Lymphangioendothelioma* arising from the lining of the sinuses of the lymph node, will be considered later among the tumors of the lymph nodes.

**Treatment**—Treatment is by excision. The tumors may recur if this is inadequate. The endotheliomas are very susceptible to radiotherapy which is also employed after excision.

## THE LYMPH NODES

### LYMPHADENITIS

Lymphadenitis is an inflammatory process involving the lymph node. Acute and chronic forms are recognized. The acute forms are more commonly due to infection by pyogenic cocci although various other pathogenic organisms may induce the characteristic features of inflammation. The chronic forms are due to tuberculous syphilis cancerous invasion or to organisms of

low virulence. Since many differing bacteria can cause lymphadenitis there are varying intermediate forms. The lymph nodes may be regionally involved for example subsequent to lymphangitis of the extremities (Figs 103 and 104) or they may be generally affected as in secondary lues.

### ACUTE LYMPHADENITIS

Acute lymphadenitis is due in most instances to a lymph borne infection. Blood borne infections and those resulting from direct trauma are rare. Among the causative organisms which have been recognized are the streptococci staphylococci the Duerrey bacillus *Treponema pallidum* and *Bacillus tularensis*. The portal of entry of the infecting organisms is usually readily demonstrated. It is important to remember that this is the principal feature of the whole disease. This and the consequent lymphangitis have been considered. On the other hand the lymphatic vessels which carry the organisms to the lymph nodes are usually unaffected. This is seen particularly in upper respiratory infections or in acute tonsillitis with subsequent acute cervical lymphadenitis.

The infected nodes become hyperplastic, enlarged and more vascular than normal. At first and throughout moderate infections they remain freely movable and discrete. In severer infections the surrounding connective tissue is involved. The nodes may then subsequently become matted together and adherent. If a virulent infection spreads from the nodes into the adjacent tissues cellulitis may develop. The inflamed nodes have a tendency to suppurate in which instance local abscesses are formed. Resolution usually is complete in the non suppurative forms. In nodes where the hyperplastic reaction has been severe a subsequent fibrosis may follow. This results in a sclerosed painless node. Suppuration may progress to involve the overlying skin which becomes red and inflamed. In such instances spontaneous rupture may follow. Organisms may remain in the nodes even after resolution, to result eventually in a recurrence.

**Symptoms**—Clinically the manifestations of acute lymphadenitis and its sequelae vary with the type and virulence of the causative organisms. The disease is more commonly

ity resulted in fairly large ovoid tumors in the submaxillary region

*Chancroidal bubo* is an acute inguinal lymphadenitis due to the Duerer bacillus. Secondary infection due to pyogenic organisms however is known to occur. It is usually unilateral on the side to which the lymphatics from the primary sore extend. From the first the inguinal nodes are acutely inflamed. Suppuration and *inguinal abscess* are frequent. This usually occurs early in the evolution of the primary disease. It may ensue even after the original chancre has healed.

*Deep axillary abscess* originates as a suppuration within the axillary lymph nodes under the deep axillary fascia. It is to be differentiated from superficial axillary abscesses which result from infections of the axillary skin and its appendages. The primary infective lesion is commonly in the hand or more rarely in the breast. If the suppuration is extensive pus fills the axilla and burrows under the pectoral muscles. It may reach the skin through less developed areas of the usually dense axillary fascia. By traveling along the sheath of the axillary vessels it may point at the base of the neck. Diagnosis is based upon the symptoms which include impairment of function of the arm. Fluctuation may be difficult to elicit owing to the tenseness of the axillary fascia.

*Subpectoral abscess* arises through suppuration of the subclavian lymph nodes. These lie about the upper margin of the pectoralis minor muscle anterior to the costoclavicular ligament. Infection reaches them from the intermediate axillary nodes directly from the breast or along lymphatics accompanying the cephalic vein. The abscess occupies the apex of the axilla. It may lie in front of or behind the pectoralis minor muscle. It may follow an infection of the hand. Diagnosis is based on the presence of the primary infection and the development of a subsequent tender swelling below the inner part of the middle third of the clavicle. If the pus migrates downward between the two pectoral muscles a swelling may appear at the lateral margin of the pectoralis major muscle. It is to be differentiated from axillary abscess and from arthritis of the shoulder.

*Retropharyngeal abscess* follows suppuration of the retropharyngeal lymph nodes. It occurs most frequently in infants.

**Treatment**—The treatment of acute lymphadenitis consists in removing the cause supporting the patient and relieving the local inflammation. If the original portal of entry is promptly recognized and adequately managed the source of the infecting organisms is abolished. The lymph nodes are then better able to cope with the infection in the absence of repeated reinfection. The primary infections are varied and require correspondingly different treatment. In some instances they may be completely removed for example by extracting an abscessed tooth or later by tonsillectomy. In others they may be rapidly cleared by more conservative treatment as by the incision and drainage of an infected hand. Hot moist dressings and rest will usually clear up a chronic suppurating ulcer.

The general resistance of the patient may be supported by rest. Hospital care is of advantage as the rest should be general as well as local. Proper care and attention to the diet should be supplemented by the liberal administration of fluids.

The local lymphadenitis responds best to hot moist dressings. Under this regimen resolution often ensues within a few days. In other cases however suppuration occurs. There is a difference in practice as to the course to be followed in the event of suppuration. Too early incision and drainage may spread the infection. On the other hand too great delay may result in the burrowing of the pus and spread of the infection as well as other complications. If abscess formation is progressing satisfactorily and there are no systemic symptoms incision is best delayed until the suppurating lymph node is converted into a sac of pus and the surrounding induration has practically disappeared. At this time the abscess membrane should be well developed so that the abscess may be explored and loculations cautiously broken. Curettage and all unnecessary trauma should be avoided.

The abscesses are best opened by *Hilton's method* (1863). The skin and superficial fascia alone are incised. By blunt dissection the abscess wall is exposed or if deep indicated by the tip of the blunt hemostat. The

tip is thrust through the abscess wall and opened and the hemostat withdrawn. A soft rubber drain is inserted. This method is of particular value in the neck, axilla and groin where important structures surround the lymph nodes. Deep axillary abscess may require in addition incision of the axillary fascia and tube drainage. A subpectoral abscess should be opened by an incision along the lateral margin of the pectoralis major muscle and drained by a tube extending up between the two pectoral muscles. Retropharyngeal abscess is best opened through the mouth and pharynx by Hilton's method.

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#### CHRONIC LYMPHADENITIS

Chronic lymphadenitis is a disorder which may be the sequel of repeated acute attacks which are the result of prolonged infection by organisms of low virulence or it may be due to syphilis, malignant invasion or tuberculosis. The common form is non-specific and involves the regional nodes draining an area of chronic infection. It is noted for example in children with chronic sculp infections. The nodes in the posterior triangle are enlarged, firm and painless. They may be adherent or even fused. The condition is frequently detected in the groin during a routine physical examination as a sequel to chronic infection or uncleanness of the genitalia. Such nodes, particularly in children, are predisposed to tuberculous infection. It is difficult to distinguish them in some instances from tuberculous nodes. This is best accomplished by biopsy and microscopic examination. *Treatment* consists in eradicating the source of infection and attention to the general health. If the nodes do not disappear after adequate measures, tuberculosis should be suspected.

*Non tuberculous granulomatosis* has been described as a form of chronic lymphadenitis. It is difficult to regard this as an entity either clinically or from pathologic criteria. Specific causative organisms are lacking. There is a decided resemblance to tuberculosis yet tubercle bacilli are not found. The nodes tend to soften, break down and form

sinuses. The greenish and tenacious pus resembles that found in tuberculous nodes. *Treatment* is by radiotherapy or excision with satisfactory improvement.

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**Syphilitic Lymphadenitis** — Syphilitic lymphadenitis occurs locally in the primary stage generally in the second stage and rarely in the third stage of this disease. Subsequent to the evolution of the primary chancre the regional lymph nodes gradually increase in size forming the *inguinal bubo*. Microscopically, troponemes may be demonstrated and there is resultant lymphoid and endothelial hyperplasia. Fibrosis subsequently ensues and may result in atrophy of the nodes. Clinically the glands are firm and tender. They do not suppurate unless a mixed infection occurs. In that event they may be painful.

During the secondary stage there is general enlargement of the lymph nodes. They are firm, non-adherent and easily palpable. During the early stages certain of the nodes may be tender but as the process advances they become insensitive.

During the third stage gummas may form within the lymph nodes. These are rare with modern diagnosis and antiluetic treatment. Rarely massive gummatous enlargement of the abdominal nodes occurs.

The *treatment* is that of the fundamental disease. The lymph nodes respond rapidly to active antiluetic treatment unless they are sclerosed or secondarily infected.

**Cancerous Lymphadenitis** — Cancerous lymphadenitis is a chronic form due to the invasion of the lymph nodes by metastatic malignant cells. These produce changes in the nodes by aggregation and multiplication as well as by induced inflammatory changes. The malignant cells are carried in the lymph stream from the primary lesion and usually lodge first in the peripheral sinuses of the convexity of the node. Later the deeper sinuses of the node become filled, the cells proliferate and the normal structure is obliterated. Inflammatory changes due to the reaction of the endothelial reticular and lymphoid cells to the foreign can

cer cells occur. Fibrosis often is evident. The cancer cells pass through the node as may be demonstrated microscopically within the efferent lymphatic vessels at the hilum.

Clinically the primary cancer is usually obvious. In certain patients with cancerous submaxillary lymphadenitis it may prove most difficult to demonstrate. This is due to the fact that a small symptomless carcinoma is hidden in the nasal cavity, the accessory sinuses or the nasopharynx.

The carcinomatous nodes are at first firm, enlarged, discrete and non-adherent. As the proliferating cancer cells invade the capsule of the node it becomes adherent. Adjacent nodes thus fuse to form a large hard mass. As a result of secondary infection and suppuration this mass may form a large abscess requiring evacuation.

*Treatment*—The treatment is by radium and by excision. Both radium and roentgen therapy have been widely employed. Their effects depend on the type of malignancy. Excision is often a matter of judgment depending on the character of the primary lesion as well as the extent of the metastases.

*Not all the enlarged regional lymph nodes that receive lymph from a carcinoma are carcinomatous.* This is a significant clinical fact. Since the primary carcinoma is often ulcerated and frequently infected, the lymph flowing from it bears numerous organisms. These cause in varying degree an inflammatory process within the nodes. Thus their enlargement may be entirely inflammatory. Such a fortunate occurrence for the patient, however, cannot be trusted.

**Tuberculous Lymphadenitis**—Tuberculous lymphadenitis is one of the more common manifestations of tuberculosis which frequently invades the lymphoid tissues. It is often encountered particularly in children and in young persons whose general health is poor because of inadequate food and unsatisfactory living conditions. It involves most frequently the cervical lymph nodes which indicates the significance of the mouth and pharynx as portals of entry. Carious teeth, the tonsillar crypts and the other lymphoid tissues of Waldeyer's ring present favorable regions through which the tubercle bacilli may enter the lymphatic vessels. Thence the organisms are carried

by the lymph stream to the upper cervical lymph nodes and particularly to the superior deep cervical and submaxillary groups. The retropharyngeal nodes may also be invaded from the nodes in these groups; the infection spreads downward along the deep cervical chain. The disease is usually bilateral. In children the bovine type of organism appears to be the usual invader. This means milk-borne infection. In adults in whom the disease is much less frequent, the bacilli are usually of the human variety. Tuberculous cervical lymphadenitis formerly known as scrofula is said to be less common than it was fifteen years ago. This may be due to the widespread removal of tonsils and adenoids which are without much doubt important portals of entry and to the more universal custom of pasteurizing milk.

The pathology exhibited by the infected nodes is variable. This is dependent on the virulence of the organisms, the amount of reaction of the endothelial, reticular and lymphoid cells and the previous condition of the nodes following chronic septic infection. In one form the greatly enlarged nodes present little evidence of specific tuberculous infection. Microscopically the appearance is that of hypertrophy and tubercles are rare. These nodes are differentiated with difficulty from the malignant lymphomas. In another form the characteristic tubercles are frequent. Caseation is evident; fibrosis has occurred and the lymphoid and epithelioid cells have increased. The tubercle bacillus may sometimes be demonstrated. Caseation commences as pinpoint foci which enlarge, coalesce and finally convert some of the nodes into a soft caseous mass. The capsule, however, is firm and thickened as a result of fibrosis. Peradenitis results in adherence to the surrounding nodes and to the adjacent structures. The progress of caseation is variable.

The involved nodes are variable in their microscopic picture. They may progress in three ways. First they may manifest preponderant fibrosis and gradually shrink to become firm, adherent nodules. Second, a secondary pyogenic infection may be added with a resultant suppuration and its sequelae. Third, the caseated mass may liquefy and form a tuberculous cold abscess. Cal

cification may occur in the sclerosing nodes or in those revealing caseation

The abscessed glands become adherent to the overlying skin which becomes involved and ulcerates. Discharge of the tuberculous pus follows with the formation of a sinus. The edges of the ulcer appear unhealthy because of the bluish undermined margin and the pale soft granulation tissue. A thin watery discharge is noted. Certain glands with calcification may cause a more profuse purulent discharge since the calcified masses act as foreign bodies. This clears when the sinus is curetted and the deposits are removed.

*Clinically* the onset of tuberculous lymphadenitis is rarely recognized as there is no accompanying general symptomatology. The infection is thus insidious. The first evidence to appear is the gradual enlargement of the lymph nodes situated about the angle of the jaw. These may be even 2 cm in diameter easily palpable freely movable and of normal consistency. They are not ordinarily tender and may be found on both sides. At this stage it is most difficult to distinguish them clinically from the enlarged nodes of chronic septic infection. The tonsillar gland lies in this region and there may be chronic tonsillitis. Biopsy with subsequent microscopic investigation is the only certain procedure.

As the disease progresses the adjacent nodes enlarge and swelling is evident. At first they are discrete and not adherent. If the foci of infection are properly treated and the gradual spread subsequently continues it is probable that the infection is tuberculous. Later as fibrosis occurs certain of the nodes become firm. It is difficult to determine caseation. Later abscess formation is recognized by softening and fluctuation.

*Axillary tuberculous lymphadenitis* is occasionally seen. It follows the evolution of an anatomical tubercle with a resultant ascending lymphangitis. It may ensue as a sequel to tuberculosis of the breast which is rare. The axillary nodes enlarge and fuse and may suppurate.

*Mesenteric tuberculous lymphadenitis* is commonly known as *tabes mesenterica*. Children frequently present some enlargement of the mesenteric nodes. It is difficult to

estimate the proportion of these that are tuberculous. It is perhaps more common than is recognized. The nodes present the characteristic pathologic changes including calcification. This is readily recognized roentgenologically. It is sometimes found in persons in whom tuberculosis has not been suspected.

Tuberculosis of the peribronchial nodes can likewise be recognized roentgenologically. It is not uncommon as revealed by microscopic studies of necropsy material. Tuberculosis rarely involves the inguinal nodes. It is to be kept in mind however in differentiating inguinal lymphadenopathy.

*Treatment*—Prophylaxis is important in the treatment of tuberculous lymphadenitis. Since the infection is so frequently bovine an uninfected milk supply is of prime consequence. Attention to the mouth and pharynx the principal portals of entry consists in proper care of the teeth and attention to the tonsils and adenoids. In the incipient disease the same measures hold since in that manner foci of infection may be eliminated. Numerous remedies have been tried for the advancing disease. Controlled heliotherapy using sunlight or the quartz lamp is of value. Bringing the child from an unhygienic home with inadequate food to a well organized institution where good care is provided usually results in improvement. Tuberculin has been extensively used but the results are still uncertain. Roentgen therapy is of value and it will be discussed later.

Early and complete excision of the infected cervical nodes is receiving increased attention. This requires skillful dissection but removes the source of further progress to other nodes. In certain instances it is curative. However unless thoroughly accomplished infected nodes may be left behind. The excision of advanced tuberculous nodes is a laborious procedure. The adhesions encountered call for not only skillful dissection but also an adequate knowledge of the anatomy of the neck. In patients with enlarged non progressive nodes it is often accomplished by experienced operators with resultant success. During the late stage curettage of discharging sinuses and of the attached broken down nodes often results in prompt healing.



*Röntgen therapy of cervical lymphadenitis* is to be considered as a useful form of treatment. The development of modern apparatus and modern technique has simplified the treatment and improved the results. Pfahler has carefully summarized the results obtained by treating 333 patients with both acute and chronic forms of varying degree—193 of these had been diagnosed as tuberculous. 42 per cent had postoperative recurrences. An unusually high percentage of those who returned for investigation showed improvement or were cured. Hospitalization is unnecessary and but few exposures are required. Softening is treated by excision through a small incision. Atrophy and telangiectases may now be avoided. Electrothermic destruction of old sinuses and thickened red scars is followed by one or two roentgen exposures.

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#### VENEREAL LYMPHOGRANULOMA

Venereal lymphogranuloma commonly known as *lymphogranuloma inguinale* or the sixth venereal disease involving particularly the lymphatic system of the genital and anorectal regions was originally described by Durand Nicolas and Favre of Lyons in 1913. Stannus' excellent monograph presents a summary of the information available up to 1933. More recent observations have been made by von Haam and his associates of New Orleans.

Venereal lymphogranuloma is a contagious disease that is acquired venereally and is caused by an ultramicroscopic filtrable virus. Experimentally it may be transmitted to certain laboratory animals. It is recognized and differentiated particularly by the nature of the *tree skin reaction*. Care should be taken not to confuse it clinically with *granuloma inguinale* which does not involve the lymphatic system but rather the pudendal skin and subcutaneous tissues and which reveals the characteristic Donovan bodies.

The initial lesion on the genitalia is small and usually herpetiform and may be transitory. Lymphatic dissemination follows with involvement of the regional lymph nodes and

the adjacent connective tissues. There is evidence of an even wider systemic spread (von Haam). Locally there ensues a characteristic subacute inflammatory process which becomes productive and chronic. This usually results in the formation of multiple small foci of suppuration with subsequent tiny fistulas.

The associated constitutional symptoms are variable and are usually noted during the stage of lymphatic invasion. Fever, rigors and sweats occur at intervals, nausea and vomiting. These result in loss of weight, lassitude and prostration.

In men the usual localization in the inguinal nodes gives rise to a characteristic clinical picture termed *climatic bubo*. With the development of subsequent extensive lymphatic blockage, elephantiasis of the penis and scrotum may follow.

In women there is more frequent involvement of the intrapelvic lymph nodes. As this progresses the syndrome known as *elephantiasis* may ensue characterized by elephantiasis and ulceration about the vulva and in the anorectal region. This may lead to inflammatory stricture of the rectum.

Von Haam has analyzed the principles of treatment. Surgical excision of the mass of infected lymph nodes in the groin may be recommended since beneficial effects have been demonstrated. Abdominoperineal resection with colostomy has been tried for the rectal stricture. Treatment during the late stages is far from satisfactory. Consequently prophylaxis is most important.

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#### TUMORS OF THE LYMPH NODES

Enlargement of the lymph nodes follows proliferative changes occurring within their component tissues. In one group of lymphadenopathies the proliferative changes are induced by infection. This may be readily demonstrated. An example is presented by the adenopathy of *chronic septic lymphat-*

*enitis* These nodes exhibit a varied microscopic picture and were the pathogenic organisms lacking would be distinguished in certain instances only with difficulty from certain neoplastic nodes. In a *second group* although the microscopic picture resembles in some respects that of an infectious lymphadenitis, no specific infecting agent has thus far been found. In this group undoubtedly consequently exists. Certain features point to malignant disease, others suggest infection. As a result classification on a rigid pathologic basis is difficult principally since the etiology is not clear. The outstanding example of this group is *Hodgkin's disease*, the true nature of which is still a matter of controversy. In the *third group* the cellular multiplication is clearly neoplastic. There is evidence of invasion and of deposits in other structures. The best example is found in *lymphosarcoma*.

*Lymphoma*, a term used to designate a proliferative tumor of lymphoid tissue, may be applied to lymph node tumors. It is however non-specific and should be qualified. The group of lymph node tumors which are not clearly due to infection should be considered as malignant. They grow without restraint, deposits occur and treatment is ineffective. They have consequently a high mortality rate. Future investigation may show that they are due to some obscure disease of the blood-forming organs or an infectious basis may be unquestionably established. Nevertheless for the present it is expedient to group them together as the *malignant lymphomas*.

#### HODGKIN'S DISEASE

Hodgkin's disease was described as a clinical syndrome in 1837. This name was given it by Wills in 1866. One or possibly two, of the original seven cases which Hodgkin reported are now regarded as valid examples of the present conception of the disease. Two appear to be tuberculous, three would seem to correspond to forms of leukemia. It has been the task of subsequent investigations to separate the differing members of the original group. The leukemias were differentiated in 1846 by Virchow on the basis of the great increase in the leukocytes. Cohnheim separated the aleukemic form in 1866, designating it *pseudoleukemia*. The clinical picture was similar to that of leukemia, however the characteristic blood findings were lacking. The relation to tuberculosis was reintroduced by Sternberg in 1898, who regarded the inflammatory form as due to the tubercle bacillus. In 1907 Dorothy Reed characterized the cellular appearances of the in-

volved nodes and set forth a reasonable basis for the identification of the disease.

One of the results of the uncertainty has been the origin of a number of terms to designate the disease. Wunderlich used multiple *lymphadenoma* without leukemia. Blioth gave it the name *malignant lymphoma*. Sternberg introduced the term *lymphogranuloma*. There have been other terms and other combinations. Although the name Hodgkin's disease is far from ideal, perhaps it will serve as well as any term until the true nature of the syndrome has been established.

Hodgkin's disease is characterized by progressive enlargement of the lymph nodes, fever which is more pronounced in the terminal stages, moderate anemia and often a fatal outcome. It affects those of all walks of life of any age and of either sex. It is more frequently observed however in young males. It is not inherited and there is no evidence of direct contagion. Its frequent occurrence in the cervical nodes suggests an oropharyngeal portal of entry. The specific etiologic agent is unknown.

Pathologically, the early enlargement of the nodes is characterized by lymphoid hyperplasia. This is so extensive that the normal appearance of the node is soon lost. It is sometimes difficult to differentiate these nodes microscopically from chronic septic nodes. Later the Dorothy Reed cells become evident and many eosinophile leukocytes. At this time the microscopic appearance is characteristic with the added fibrosis and complete disorganization of the normal lymphoid structure. During the early stages the nodes are discrete, freely movable and of a homogeneous grayish appearance when sectioned. They have a peculiar elastic consistency on palpation. When exposed for biopsy the appearance of a group is characteristic. This stage may persist for a long time. Later progressive scarring ensues and the nodes fibrose and may fuse. Lymphoid cells invade the capsules and further dissemination may occur. During this invasive stage any tissue of the body, even bone and the central nervous system may be secondarily invaded. This termination presents the characteristics of malignancy. It has been so recognized in fact. Ewing has designated it *Hodgkin's sarcoma*. The entire pathologic picture is perhaps best rationalized when considered as an infectious granuloma with subsequent malignant change.

**Symptoms**—Clinically the onset is in

sidious. The patient may notice some malaise. However, the discovery of the disease is in finding the enlarged painless nodes. These are usually originally observed in the neck and on one side. The progressive enlargement is ordinarily slow. Gradually other groups of nodes enlarge and then nodes in other regions. Fulminating forms are described. The characteristic cervical axillary and inguinal nodes are easily palpable. The x-ray readily demonstrates the enlarged mediastinal nodes. The spleen enlarges and is palpable at the costal margin in about half of the late cases. The duration may be a matter of months. The usual course is from two to four years. It may persist in sclerosing forms for many years. The termination is characterized by widespread invasion of the entire body.

The fever is of the Pel-Ebstein type. There is marked lassitude and weakness. The basal metabolism may be elevated in progressive cases. Pruritus is commonly encountered even early in the disease. In patients with unexplained weakness and fever Hodgkin's disease should be considered. Pigmentation may appear and cutaneous granulomas. Hemorrhage is rare. Terminally emaciation and weakness reach an extreme degree.

According to Wiseman three types of blood pictures are encountered. In about half the patients there is found leukopenia, lymphopenia, eosinophilia of from 8 to 10 per cent and monocytosis. The anemia is of the hemoglobin type. The erythrocytes are decreased and the color index is lowered. The platelets are increased. In another 40 per cent the findings are similar save that eosinophilia is lacking. In 5 per cent there is neutrophilic polymorphonuclear leukocytosis, the count ranging from 10,000 to 40,000. There is a relative decrease in the lymphocytes, monocytes and eosinophils. About 5 per cent of the pictures are mixtures of these.

**Treatment**—Treatment by medication has little effect. Iron and arsenic have been tried. Early excision followed by intensive radiotherapy has been practiced. Since lymphoid tissue is so susceptible to radium and x-ray therapy this form of management is the most common. Even these results are unsatisfactory.

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## LYMPHOSARCOMA

Lymphosarcoma is a malignant tumor originating within the lymph nodes. It may arise in other lymphoid tissues for example in the tonsil. Its existence as a clinical entity has been questioned. This applies particularly to the generalized form *lymphosarcomatosis* described by Kundrat in 1893. Others regard the localized form as a primary sarcoma. It presents certain resemblances to Hodgkin's disease. There is evidence of blood stream metastasis. In certain cases the tumor cells have been found in the blood stream. This variation has been termed *leukosarcoma*.

Lymphosarcoma of the localized form presents a varying microscopic picture, depending on the type of cell of which the tumor is composed. Three varieties are recognized: (1) The lymphoblastoma type is composed of large round cells, the lymphoblasts; (2) the lymphocytoma is formed by small round cells; and (3) the third form originates from the reticular cells and is designated a reticular cell sarcoma. These three forms are not distinguishable clinically.

The disease is more common in males. It occurs at all ages but usually during middle life. Local infiltration occurs early and is the common finding. Later fever may occur. During the early stages it is difficult to differentiate it from Hodgkin's disease or forms of leukemia. The mediastinal cases are recognized by means of the x-ray. The disease is uniformly fatal and the course usually shorter than that of Hodgkin's disease.

**Treatment**—Treatment is by excision of the localized forms with subsequent intensive radiation. X-ray treatment may be of benefit. All treatment is unsatisfactory and cures are unknown.

## LYMPHATIC LEUKEMIA

Lymphatic leukemia is a blood disease characterized by progressive enlargement of the lymph nodes and a great increase in the number of circulating lymphocytes. There is usually a moderate anemia. In the *aleukemic form* the total leukocyte count is not characteristic although there is lymphocytosis. Other lymphoid tissues are involved.

The lymph nodes are greatly enlarged. They may adhere to one another but do not fuse. They do not adhere to the skin or ulcerate. The involvement is general and usually occurs throughout the body. Biopsy reveals *soft discrete nodes*. When sectioned these are moist, grayish and of homogeneous consistency. Microscopically, the reticular framework is packed with lymphocytes. These vary in size in different nodes. It is thought that nodes containing a preponderance of large lymphocytes occur in the more acute conditions.

Two types are recognized. An acute form occurs in children and may prove fulminant and rapidly fatal. The lymph nodes rapidly enlarge. They are soft and do not fuse. Subcutaneous and submucous hemorrhages appear. Fever occurs and anemia is marked. The chronic form occurs in older persons. It is intermittent and may continue for years. Anemia is noted and also weakness. The enlarged lymph nodes and the blood picture are characteristic.

**Treatment**—Treatment of the acute form is unsatisfactory. Medication is of no avail. Radiotherapy of the chronic forms is at best palliative.

## ENDOTHELIOMA

Endothelioma develops as a primary tumor originating in the endothelial lining of the lymph sinuses within the lymph nodes. It is rarely encountered. It has been confused with secondary carcinoma of the node. It may become generalized. It is not diagnosed clinically and as a rule is only recognized during the study of microscopic sections of the nodes. In the neck it becomes extensive and metastases occur. Endotheliomas are particularly susceptible to radiotherapy. They have been discussed under lymphatics.

*Chloroma* is characterized by the occur-

rence of greenish tumors of the skull vertebrae, ribs and other organs accompanied by a leukemic blood picture. It appears to be a systemic disease of the lymphatic system. The tumors are of mesenchymous origin. It occurs chiefly in young males, runs a rapid course and terminates fatally. The lymph nodes and spleen are enlarged. Invasion and secondary deposits occur. The color of the tumors is characteristic. It has been regarded as due to transformed blood pigment or to fatty products of cell metabolism. Greenish refractive lipid granules are found in the tumor cells. Chloroma presents a leukemic process with a definite neoplastic trend. It belongs with the sarcomas of the blood-forming organs. The etiology is unknown.

## THE DIFFERENTIAL DIAGNOSIS OF LYMPHADENOPATHY

A number of significant features should be considered in making a differential diagnosis of a given lymphadenopathy. These have been recently summarized by Wiseman, an abridged account of whose work is here presented. Knowledge of the tributary lymphatics is indispensable as it aids in determining the portal of entry for malignant cells or for infection. Five differentiating criteria are then important: fever, characteristics of the nodes, splenomegaly, the blood picture and the biopsy findings.

*Fever* indicates an infectious lymphadenopathy. It is however present in acute leukemia, serum sickness and in the terminal stages of any lymphadenopathy. The septic type indicates suppurative lymphadenitis. The Pel-Ebstein type suggests Hodgkin disease. On the other hand, absence of fever does not rule out infection.

Significant *characteristics of the nodes* include tenderness, distribution and consistency to palpation. Tender nodes indicate infection and resultant inflammation. Distribution may be general or local. Local enlargement without fever or tenderness suggests lymphosarcoma, metastatic malignant growth, benign hypertrophy, tertiary syphilis or Hodgkin's disease. Local swelling with fever and tenderness indicates tuberculosis or pyogenic lymphadenitis but never Hodgkin's disease. Generalized lymphadenopathy

without fever occurs in the chronic leukemias the afebrile phases of Hodgkin's disease and the benign hypertrophies. Generalized enlargement with fever may mean syphilis. Hodgkin's disease, infectious mononucleosis, generalized lymphatic tuberculosis (which is rare), serum sickness or an acute phase of leukemia.

Fluctuant nodes may be tuberculous or pyogenic. In leukemia the nodes are always discrete and elastic. Some forms of metastatic carcinoma result in hard unyielding glands as do sclerosing types of Hodgkin's disease but many do not.

*Splenomegaly* is a clinical aid. A large firm spleen accompanied by generalized enlargement of the nodes nearly always signifies leukemia. In Hodgkin's disease the spleen is palpable in about half the cases. In infectious mononucleosis the spleen may be somewhat enlarged. Occasionally lymphosarcoma presents a palpable spleen. Chronic cervical enlargement with a palpable spleen strongly suggests leukemia or Hodgkin's disease.

The *blood picture* is one of the most important criteria but it must be carefully studied. It is normal in the malignant enlargements save in the advanced stages or when accompanied by leukemia. In leukemia it is diagnostic. A neutrophilic leukocytosis is evidence that the lymphadenopathy

is infectious. Lymphatic tuberculosis presents lymphocytosis, monocytosis and mild anemia of the hemoglobin type. Hodgkin's disease reflects lymphopenia, eosinophilia and monocytosis with usually leukopenia and marked anemia. Eosinophilia and lymphocytosis with normal red and white cells suggest syphilis. Marked lymphocytosis, Reidier nuclei and normal red cells suggest infectious mononucleosis. Pyogenic lymphadenitis presents principally a neutrophilia. The non-infectious non-malignant lymphadenopathies are characterized by normal total counts but a relative lymphocytosis. Aleukemic lymphatic leukemia may be eliminated by demonstrating the concurrent disease responsible for the lymphatic reaction.

*Biopsy* may be necessary. The largest node should be completely removed. It is well to remember that the cervical nodes lie deeper than the superficial fascia and among important structures. Careful study of biopsy material coupled with painstaking clinical investigation will doubtless lead to more light in an admittedly uncertain field. There too lies a way to clinical progress.

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## XII. THE ENDOCRINE SYSTEM

### DISEASES OF THE THYROID GLAND AND THEIR MANAGEMENT

#### EMBRYOLOGY, ANATOMY AND PHYSIOLOGY

**Embryology**—The thyroid gland\* is a derivative of three primordial structures one median and two lateral. The median thyroid component which contributes the most important part of the thyroid gland first appears as a well-defined fold or evagination in the ventral wall of the primitive pharynx at the point at which the *tuberculum impar* and the two lateral anlagen of the tongue join between the first and second pharyngeal pouches. This occurs in the embryo of 3 to 5 mm., or before the second pair of somites has been definitely separated off and according to Weller consists in a proliferation rather than in a primary differentiation of pharyngeal cells (entoderm) (Fig 105). As growth takes place the fold becomes a spherical body which in turn soon becomes bilobed and for a time is continuous with the pharynx by a narrow pedicle. The point in the pharynx to which the pedicle is attached is later indicated by the depression in the tongue the *foramen caecum* behind the apex of the V row of the circumvallate papillae. This pedicle normally disappears as the median thyroid epithelium sheet like in form descends in the neck finally to occupy a position astride the upper portion of the trachea. Occasionally however the pedicle persists in part or in whole to form the *thyroglossal duct* a narrow tube extending through the center of the tongue for a variable distance toward the thyroid gland.

The lateral thyroid components arise as evaginations from the fourth entodermal pouch and cannot be identified until the embryo contains more than twenty somites. These situated laterally and inferiorly with regard to the median body move forward and upward to meet the posterior surface of the latter. According to Weller, the three primordial structures fuse in the

13 mm embryo into a morphologically single structure which however histologically is composed of two distinct types of tissue. The median thyroid component consisting at this stage of the more differentiated tissue, undergoes little change but that of growth until the lateral thyroid bodies in their entirety, are similar in appearance. Then begins differentiation of the sheets of epithelium into follicles throughout the entire gland.

**Anatomy**—The thyroid gland which is red-fleshly in appearance and is the largest of the ductless glands is normally concealed by the overlying infrahyoid and sternocleidomastoid muscles and lies in the lower third of the neck partially encircling the upper portion of the trachea and the lower portion of the larynx. Its configuration is roughly that of a butterfly consisting of two lateral lobes connected in front of the trachea by a narrow strip the *isthmus*. Although the organ is symmetrical in plan not infrequently one lobe usually the right is appreciably larger than its fellow. The size and weight of the gland vary greatly depending on the age sex physiologic status and place of residence of the person. The average size may be roughly stated as follows: vertical diameter 3 to 6 cm., anteroposterior diameter 2 to 3 cm., transverse diameter (whole organ), 6 to 7 cm. Normally its weight ranges from 20 to 60 gm., averaging about 40 gm. The lateral lobes one on either side of the trachea are irregularly pyramidal or conical in form presenting three surfaces a convex anterolateral a grooved posterior and a concave internal. The upper extremity of the lobe narrows to an apex the *superior pole*. The lower extremity which is thick and rounded is referred to as the *inferior pole*.

The isthmus commonly about 2 cm in breadth and 0.5 cm in thickness covers usually the second and third tracheal rings and joins each lateral lobe at the junction of its middle and lower thirds. This likewise varies considerably in size shape and situation and occasionally is absent.

In at least 50 per cent of cases there is present an upward prolongation of thyroid tissue the *pyramidal process* which arises from the isthmus or the anteromedial border of either lobe and extends as a ribbon or cord like structure just lateral to the median lobe for a variable distance toward the hyoid bone. Occasionally it is free of any connection with the thyroid gland. The surgical importance of the pyramidal process lies in the fact that since its position is above the operative field usually exposed in an operation for goiter it may be readily overlooked during the resection. In that event almost invariably the process subsequently enlarges to produce a disfiguring deformity to annoy the patient and to plague the surgeon.

The thyroid gland is completely encased in a fascial sheath derived from the middle layer of deep cervical fascia and commonly referred to as the *surgical capsule* in distinction to differentiate it from the *true capsule*. The latter is a very thin transparent covering

\* There has existed among embryologists a sharp division of opinion with regard to the mode of development of the thyroid gland in man. The controversy has centered about the question as to whether the thyroid gland is derived solely from a single median primordial structure or whether its derivation includes three two lateral and one median. The earlier investigators Born (1883) His (1883) and others concluded that the thyroid gland arose from three primordial structures. Further researches in comparative embryology led others to deny that the lateral post-franchial bodies played any part in the development of the thyroid gland. More recently, however the view has prevailed that although the lateral bodies do not function in the lower vertebrates in man they fuse with the median body and form an integral part of the definitive thyroid gland.

inseparably attached to the parenchyma of the gland. The surgical capsule is attached to the true capsule by loose areolar tissue which offers but little resistance to its separation during the course of an operation. For the most part, this fascial sheath is thin in places imperfectly formed it readily yields to enormous enlargements of the gland and at times permits the escape of adenomatous projections beyond its confines. Contained within this fascial compartment are the thyroid gland the upper extremity of the trachea the cricoid and thyroid cartilages and commonly all four parathyroid glands. The inferior laryngeal nerve is generally considered to run within the compartment, but according to Pool and Falk it actually lies outside, between two layers of fascia split off posteriorly from the surgical capsule. To the trachea and cricoid and thyroid cartilage the thyroid gland is so firmly attached by means

of the thyroid artery and occupies a position for the most part medial to the gland. Usually the nerve is posterior to the gland only in relation to the inferior pole. The medial position of the nerve becomes more pronounced in goitrous glands.

**Structure.**—The fibroelastic capsule, which envelops the gland completely, gives off numerous septulae which together with blood vessels, lymphatic structures and nerves ramify through the substance of the gland to subdivide it into compartments of irregular size and shape. The earlier belief based on microscopic study of the occasional section held that these septulae subdivided the parenchyma into isolated portions completely surrounded by connective tissue but the recent investigations of Renbush based on study of wax models of the gland reconstructed from serial sections indicate that there are no distinct lobules but

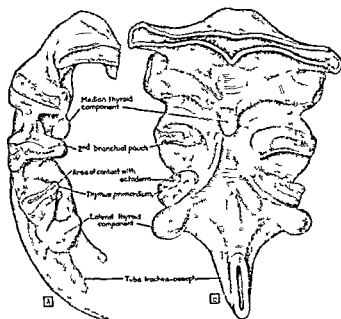


Fig. 105.—A. Lateral aspect of the pharyngeal and primordial epithelium of the 3 mm embryo. The median and lateral thyroid components are situated much farther ventrally than the other primordia. B. ventral aspect. The primordium of the median thyroid is situated just anterior to and midway between the primordia of the tonsils. The primordia of the lateral thyroids extend far laterally beyond those of the thymus components but are not in contact with ectoderm as are the latter (Weller).

of the fascial sheath and bands that it follows their movements as during the act of swallowing. Knowledge of this feature is of great importance in distinguishing clinically, tumors of the thyroid gland from those arising from other adjacent structures. Two well-defined bands of considerable consistency are the paired suspensory ligaments. These arise from the anterior surface of the lateral lobe near its junction with the superior border of the isthmus and pass upward to be attached to the anterior surface of the cricoid and thyroid cartilages. The anatomical relationship between the thyroid gland the carotid sheath the inferior (recurrent) laryngeal nerve and the parathyroid glands is of prime importance to the surgeon. The carotid sheath is commonly lateral to the normal gland and posterior or posterolateral to the enlarged goitrous gland. The nerve which normally runs in the tracheo-oesophageal groove may lie anterior or posterior to the inferior thy-

roid artery and occupies a position for the most part medial to the gland. Usually the nerve is posterior to the gland only in relation to the inferior pole. The medial position of the nerve becomes more pronounced in goitrous glands.

The structural unit of the gland is the follicle or vesicle a closed sac of varying size and shape. The follicle is lined by a single layer of epithelium normally cuboidal or low columnar which rests directly on the surrounding connective tissue without interposition of a basement membrane. Within the cell in addition to the nucleus and nucleolus are protoplasmic filaments the mitochondria, visible only by means of special staining. It has been claimed that these become more conspicuous in the active phase of the cells than in the resting phase and accordingly the activity of the gland may be judged by the conspicuousness of these filaments. Usually found filling the follicle is a viscid homogeneous acid staining substance called the phys-

ical properties of which vary according to the activity of the gland. In the very active gland the follicles are relatively small with high columnar epithelium and only partially filled with a thin poorly staining colloid whereas in the resting or sluggish gland the follicles lined with flattened cells are distended by the accumulation of a more viscid and deeply staining colloid.



Fig 106—Section of a normal thyroid

loid (Fig 106). The presence of rests of fetal cells situated between normal adult follicles as first described by Wüller and subsequently often included in descriptions of the histology of the gland is denied by Rienhoff. The latter observer has explained that a tangential section through the dome of an underlying follicle may give the appearance of an isolated group of epithelial cells.

**Blood Supply.**—The thyroid gland has an exceedingly generous blood supply (Fig 107) derived principally from the superior and inferior thyroid arteries on each side and augmented constantly by collateral vessels from the trachea and esophagus and occasionally by the *thyroid ima*, a vessel springing directly from the arch of the aorta. The superior thyroid artery, the first branch of the external carotid, joins the gland at the superior pole or medial to it and ramifies over the anterior and external surfaces sending branches into the interior. The inferior thyroid artery arises from the subclavian by way of the thyroid axis ascending in the neck to the level of the sixth cervical vertebra and passes medially behind the carotid sheath in front of or behind the recurrent laryngeal nerve to enter the thyroid gland near the posteromedial border usually at the level of the junction of the middle and lower thirds. As the artery enters the gland it divides into medial and lateral branches which anastomose freely with branches from the superior thyroid artery and with vessels from the trachea and esophagus. Commonly there is also free communication between the circulation of each lobe by way of branches across the isthmus. Surgically the collateral circulation is of great importance. In the operation of subtotal thyroidectomy, all four of the principal arteries to the gland can be safely ligated with little or no risk that the circulation to the remnant of the gland will be seriously impaired provided the remnant of the gland is not detached from the side of the trachea thereby

destroying its collateral circulation. The veins emerge from the interior of the gland to form a plexus of dilated vessels beneath the true capsule. From here there are three main channels of escape into the systemic circulation—the superior, the middle and the inferior thyroid veins. The superior veins usually two in number run along the course of the superior artery and drain into the internal jugular vein. The middle vein which is not always constant emerges as a single vein or a plexus of veins from the capsule on the lateral surface of the gland and passes backward and laterally to enter the internal jugular vein. The inferior veins usually two in number pass downward in front of or on the side of the trachea to drain into the innominate vein. Not infrequently there is an additional vein which emerges from the pyramidal lobe of the isthmus and empties into one of the anterior jugular veins.

Since the veins drain directly into the large venous trunks in the root of the neck or in the upper mediastinum a vein insecurely ligated in the course of an operation for goiter may result in aspiration into the vein of a large quantity of air, with alarming symp-

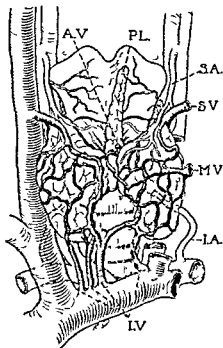


Fig 107.—Anterior view of the thyroid gland showing the arrangement of the principal blood vessels. AV, Accessory thyroid vein; SV, superior thyroid vein; MV, middle thyroid vein; IV, inferior thyroid vein; SA, superior thyroid artery; IA, inferior thyroid artery; PL, pyramidal lobe.

toms. Guthrie has reported seventeen instances of air embolism occurring on the services of twelve surgeons during the course of an operation for goiter; in six cases the outcome was fatal.

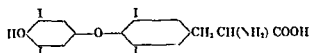
**Lymphatic Structures.**—The thyroid gland possesses a rich lymphatic circulation. From lymph spaces surrounding the follicles, intercommunicating channels run



with the interlobular septums to the periphery where they unite to form under the capsule an intricate plexus of vessels completely surrounding the gland. The vessels leave the gland principally from three portions—the superior pole, the inferior pole and the lateral aspect of the lobe and drain into nodes in the deep cervical region and into those in front of and lateral to the trachea. Occasionally lymphatic vessels empty directly into the subclavian vein without interposition of lymph nodes.

**Nerve Supply.**—The gland is innervated by fibers derived for the most part from the sympathetic system. According to Joll they leave the spinal cord with the first two thoracic roots and pass to the inferior middle and superior cervical ganglia. Non-medullated fibers from all three ganglia enter the gland as plexuses of fine fibers in intimate association with the inferior and superior thyroid arteries. It is probable that fibers from both superior and inferior laryngeal nerves also contribute partly to the nerve supply of the thyroid gland.

**Physiology.**—The function of the thyroid gland is so far as is known to elaborate thyroxine and to deliver it or a substance containing it to the blood stream. Thyroxine the active principle of the thyroid gland was isolated by Kendall in 1914 and was synthesized by Harrington in 1927. The formula assigned to it by Harrington is as follows:



H. S. Plummer in 1917 stated the following hypothesis: 1. Thyroxine is active in nearly all or all of the cells of the body. 2. Thyroxine is a catalytic agent hastening the rate of formation of a quantum of potential energy available for transformation on excitation of the cells.

The administration of thyroxine or of thyroid gland substance results in increase in the basal metabolic rate and in the physiologic phenomena that would be expected to result from this increase in the rate of transformation of energy. The pulse rate and pulse pressure are increased. The minute volume output of the heart is increased. The surface temperature of the body is increased and perspiration is increased. There is loss of body weight unless the intake of food is increased sufficiently to counterbalance the effect of the increased metabolism. There is tremor. The cholesterol in the blood

decreases in amount. If the administration of a preparation of thyroid is persisted in sufficiently long and if it is given in sufficient quantity, auricular fibrillation may develop.

Thyroxine has an effect on the myocardium that is not attributable to any effect produced through the nervous system. Priestley Markowitz and Mann found that the heart of a pup anastomosed to the vessels in the neck of a dog beat at an increased rate when the dog was given thyroxine. Markowitz and later then studied tissue cultures of pulsating fragments of heart muscle removed from chick embryos before the appearance of nerve elements in the heart. They found that thyroxine produced in these fragments a progressively greater increase in the rate of pulsation ending in some cases in fibrillation and paralysis.

Boothby has shown that following a single injection of a large amount of thyroxine the basal metabolic rate rises for about ten days after which it falls rapidly for a time then gradually until it reaches the preinjection level approximately from eight to ten weeks after the injection.

**Thyrotropic Hormone.**—There has been isolated from the anterior lobe of the pituitary gland a substance which when injected parenterally into animals causes hypertrophy and hyperplasia of the thyroid gland (Loeb and Bassett and Aron). In man this substance causes an increase in the basal metabolic rate which however is not maintained for longer than a few weeks (Thompson). The same substance administered to some animals causes exophthalmos, the degree of protrusion of the eyes being greater if the thyroid gland is removed before the injection (Marine and Rosen and Friedgood). Paulson has shown that this protrusion is due in part at least to an increase in intraorbital fluid. Recently Rundle and Pochin have found an increase in fat in the extraocular muscles and the orbital fibrofatty tissue of patients with exophthalmic goiter. Dobyns has found an increase in fat in the extraocular and other skeletal muscles of animals following production of exophthalmos by thyrotropic hormone. Rawson has found that the thyroid stimulating hormone of the pituitary body is inactivated by thyroid tissue and also by lymphoid tissue.

The inactivated hormone may be reactivated by heat.

Two series of goitrogenic substances have been found to cause hypertrophy of the thyroid parenchyma and to cause diminution of function. The action of one series which includes cabbage (Chesney, Clawson and Webster), cyanates (Marine) and potassium sulfocyanate (Rawson) is prevented by iodine. The action of the other series which includes sulfonamides and related drugs and thiouracil, thiouracil and related drugs (MacKenzie and MacKenzie Astwood) in causing hypertrophy of the thyroid parenchyma is not prevented by iodine but is prevented by the administration of desiccated thyroid or thyroxin. The thiouracil group interferes greatly with the entrance of iodine into the thyroid gland. The hypertrophy of the thyroid parenchyma is mediated through the anterior lobe of the pituitary body.

Other physiologic considerations will be taken up under the various diseases of the thyroid gland.

**Classification of Diseases of the Thyroid Gland**—The term goiter or struma is loosely employed to embrace any abnormal enlargements of the thyroid gland. Many classifications of goiter have been advocated based on etiological, functional, structural or clinical features or on a combination of two or more of these. Since most of the groupings have proved unsatisfactory in clinical practice they will not be submitted here lest the multiplicity of terms provoke unnecessary confusion. The following clinicopathologic classification founded on Plummer's conception of the diseases of the thyroid gland has proved eminently satisfactory for the grouping of the many thousands of cases seen in the Mayo Clinic.

- 1 Diffuse colloid goiter
- 2 Adenomatous goiter without hyperthyroidism
- 3 Adenomatous goiter with hyperthyroidism
- 4 Exophthalmic goiter
- 5 Thyroiditis
  - Acute
  - Chronic
  - Non specific
  - Tuberculosis
  - Syphilis
  - Actinomycosis

- 6 Myxedema
- 7 Cretinism
- 8 Malignant diseases
- 9 Congenital abnormalities

#### DIFFUSE COLLOID GOITER (ADENOMATOUS GOITER, ENDEMIC GOITER)

Diffuse colloid goiter is characterized grossly by a diffuse symmetrical enlargement of the thyroid gland and pathologically by distention of the follicles with increased amounts of colloid and flattening of the follicular epithelium.

**Etiology**—Various theories have been proposed as to the cause of diffuse colloid goiter. Marine's work in prevention of sim-



Fig. 108—A patient with a colloid goiter.

ple goiter by the administration of iodine and the work of many others along similar lines indicate that deficiency of iodine plays an important etiologic role. McCarrison's studies in India indicate a bacterial factor in the etiology of endemic goiter and Marine and Lanhart found a similar factor in the colloid goiters of fish.

**Pathology**—The thyroid is symmetrically and smoothly enlarged. The cut surface glistens from the increased amount of colloid and distended follicles are occasionally large enough to be identified with the naked eye. Microscopic sections disclose distention of the follicles with colloid that stains homogeneously. The alveolar epithelium is flattened.

**Clinical Considerations.**—Diffuse colloid goiter occurs most frequently at, or soon after, the age of puberty (Fig. 108). It is more common among females than among males. The thyroid gland is symmetrically enlarged. It is somewhat softer than the normal gland. In some instances vascularity of the gland is so greatly increased that arterial bruits may be heard over the gland. In these cases the gland is usually extremely soft. Enlargements sufficient to cause respiratory disturbances from pressure are extremely rare. The gland may enlarge from time to time, particularly during the menstrual period or during pregnancy. Colloid goiters large enough to necessitate treatment are becoming rare in this country.

There are no constitutional symptoms associated with colloid goiter. The basal metabolic rate is usually near the lower level of normal limits. It may be somewhat below normal.

The differential diagnosis offers no difficulty except when colloid goiter is associated with neurasthenia or neuroses of the types that suggest, from their symptoms, mild degrees of hyperthyroidism. The differential diagnosis in such cases will be discussed under the hyperthyroid states.

**Treatment.**—Marine has shown that colloid goiter can be largely prevented by the administration of small amounts of iodine over long periods. He has advised the use of small doses of iodine in childhood as a prophylactic against colloid goiter.

When colloid goiter has become established, iodine does not usually cause much diminution in the size of the enlarged gland. Ordinarily, however, the enlargement and bruit will subside rapidly if desiccated thyroid is given orally or if thyroxin is given intravenously. It is important to regulate the dosage of desiccated thyroid by means of repeatedly estimated basal metabolic rates. Occasionally, when the colloid goiter has been reduced, adenomas which could not be felt previously will become apparent. These ordinarily will not diminish appreciably in size with continuance of treatment. Surgical resection of the gland is seldom indicated, except in those cases in which marked obstructive dyspnea is present or in those cases in which the process is associated with adenoma.

### ADENOMATOUS GOITER WITHOUT HYPERTHYROIDISM (NON-TOXIC NODULAR GOITER)

Under the term adenomatous goiter are included the discrete, encapsulated, or partially encapsulated, adenomas of the thyroid gland, and in addition nodular enlargements of the thyroid gland occasionally are referred to as "adenomatosis." Adenomas may be single or multiple.

**Etiology.**—Adenomatous goiter occurs with greatest frequency in those geographical districts where colloid goiter is endemic. Adenomas often appear in association with or as sequelae of, colloid goiter. It is prob-

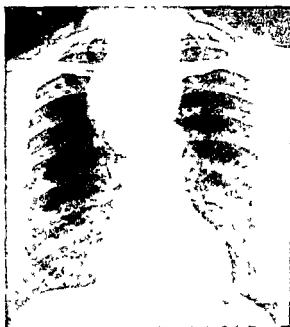


Fig. 109—Fluorogram of an intrathoracic goiter occupying a position behind the trachea.

able therefore that deficiency of iodine is one factor in the causation of adenomatous goiter. Among the views regarding pathogenesis may be mentioned the following: Adenomas may arise (1) from fetal epithelium (Wolfer), (2) as "involutional bodies" (Rienhoff), (3) from maldeveloped tissue rudiments (Kloppel) and (4) as circumscribed regenerative and compensatory new formations (Wegelin).

**Pathology.**—Adenomatous masses in the thyroid gland may be true tumors, completely or partially encapsulated, or they may occasionally be nodular masses without capsules. The tissue in adenomas may be of

the fetal type of thyroid tissue or it may be identical with the adult type of thyroid. Regions of degeneration with deposition of cholesterol crystals formation of cysts

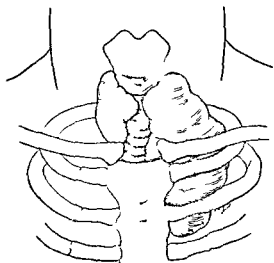


Fig 110—Diagram of a substernal goiter showing the tracheal displacement

hemorrhage deposits of calcium salts and occasionally regions of thyroiditis are found frequently in adenomas. Regions of hypertrophy of the follicular cells frequently are

appear most commonly in the first half of adult life. The gland presents a nodular enlargement usually asymmetrical which may in some instances reach a huge size. Substernal projections of the goiter should be suspected and looked for in roentgenograms of the chest whenever the lower poles of the thyroid are not easily palpable (Fig 109). In rare instances the entire goiter may be in the substernal position. Tracheal pressure and displacement are frequently seen especially when the nodular enlargement is wedged into the superior thoracic strait (Fig 110). When pressure is sufficiently great a respiratory stridor easily can be heard during forced breathing through the open mouth. Dilatation of the superficial veins of the anterior thoracic wall may occur as a result of pressure on the great veins in the neck (Fig 111).

Even small adenomas may be so situated that they cause pressure on the recurrent laryngeal nerve with resultant paralysis of the corresponding vocal cord. This may produce no symptoms and is detected only on laryngeal examination. Hypertrophy and carcinoma of the thyroid occurring in pa-



Fig 111—Photograph taken with an infra red plate showing the veins of the chest dilated as a result of venous obstruct from a substernal goiter

found in the tissue immediately surrounding the adenoma or in the adenoma itself.

**Clinical Considerations**—Adenomatous goiters may be present at birth or may become apparent at any time in life. They

tients with adenomatous goiters will be considered later.

**Treatment**—Prophylactic treatment with iodine directed against colloid goiter may reduce the incidence of adenomatous goiter.

Administration of iodine or preparations of thyroid sometimes will reduce the size of adenomatous goiters, but there seems to be no advantage in this procedure and it seems probable that the prolonged administration of iodine to patients who have adenomas of the thyroid sometimes will predispose to hyperfunction of the adenoma. Surgical removal of the adenoma is the treatment of choice.

When the adenoma is causing respiratory obstruction because of tracheal pressure it is imperative that they be removed. It is desirable to remove adenomas 1 inch (2.5 cm) or more in diameter whether they are producing symptoms or not as the risk of removal from otherwise healthy persons is negligible and the possibility of subsequent trouble from hyperthyroidism, tracheal pressure or the development of carcinoma in the adenoma is sufficiently great to make presence of the adenoma undesirable. Recurrence of adenomatous goiters occurs more frequently in those cases in which the patient is operated on before the age of twenty-five years than in those in which the operation is performed at a later period of life. Because of this fact when children and young adults have nodular goiter surgeons commonly advise that operation for the removal of the nodules be postponed until the patient is twenty-five or thirty years of age. However, Kennedy found that in twelve of sixty-two patients who were fifteen years old or younger from whom nodular enlargements of the thyroid gland were removed carcinoma was present. Such a high incidence of carcinoma of the thyroid in young persons makes necessary a careful consideration of thyroid enlargements in all cases regardless of age. The operative procedure indicated is removal of all the nodules contained in the gland. For a single adenoma unilateral resection will suffice but in the majority of cases both lobes are involved by nodular formation and bilateral resection should be performed. A nodule in the lobe which appears clinically to be the smaller may be readily overlooked if at operation the lobe is not thoroughly exposed. In that event subsequent growth of the nodule is likely to occur resulting in so-called recurrence of the adenomatous goiter.

## THE HYPERTHYROID STATES

H. S. Plummer classifies the hyperthyroid states as (1) hyperfunctioning adenomatous goiter and (2) exophthalmic goiter and recognizes these as two separate clinical entities. In hyperfunctioning adenomatous goiter the physiologic status is identical with that produced by feeding excessive quantities of desiccated thyroid.\* Exophthalmic goiter on the other hand is characterized by certain additional phenomena which cannot be reproduced by the administration of thyroid. These phenomena are (1) the ocular phenomena (exophthalmos, stare, edema of the eyelids and so forth), (2) the characteristic psychic status, (3) frequent useless purposeful movements, (4) a tendency to the development of gastrointestinal crisis and (5) the presence in nearly all cases of diffuse hypertrophy of the thyroid.

Puppel and Curtis, studying the iodine balance in toxic nodular goiter among patients maintained on a low iodine intake, found a great increase above normal in the excretion of iodine, particularly through the urine. The total excretion of iodine was greater than in cases of exophthalmic goiter in the latter condition the greatest increase in excretion was through the feces. The excretion of iodine from patients who had toxic nodular goiter simulated that of a hypothyroid patient after treatment with desiccated thyroid. Puppel, Kline and Curtis also found a decrease in excretion of calcium in toxic nodular goiter when compared with that in exophthalmic goiter.

## ADENOMATOUS GOITER WITH HYPERTHYROIDISM

### (Toxic Adenoma, Hyperfunctioning Adenomatous Goiter)

Hyperthyroidism attributable probably to hyperfunction of adenomatous tissue is prone to develop in cases of adenomatous

\* If one reasons by analogy to other ductless glands, function of an adenoma of the thyroid is reasonable. Some evidence that adenomas of the thyroid gland may overfunction are as follows: 1. In a patient who has the clinical signs from hyperfunctioning adenomatous goiter a single adenoma of the thyroid is resected. 2. The adenoma will cure the hyperthyroidism. 3. In a case of nodular goiter with a low mass of the thyroid hyperthyroidism occurred. At operation the thyroid was markedly atrophic but recurred a few days later.

goiter Plummer has pointed out in this condition the absence of the phenomena noted in the foregoing as characteristic of exophthalmic goiter He stated The primary clinical manifestations of the hyperthyroid state associated with adenomatous goiter are or are due to the reactions that must accompany elevation of the rate of energy transformation in the body (1) cardiovascular reactions that are indicative of an increased minute-volume flow of blood from the heart, (2) increased perspiration and surface temperature indicative of an elevation of heat elimination (3) increased food consumption in most instances insuffi-



Fig. 112.—A patient who has a adenomatous goiter with hyperthyroidism

cient to maintain the body weight (4) a group of findings attributable to stimulation irritability and fatigue of the nervous system The physiologic status of the patient with hyperfunctioning adenomatous goiter can be reproduced by the administration of excessive quantities of thyroid or thyroxin

**Pathology.**—In general the pathologic findings are similar to those in cases of adenomatous goiter without hyperthyroidism Regions of hypertrophy in adenomatous tissue or in the tissue outside the adenomas are somewhat more frequent in hyperfunctioning adenomatous goiter than if hyperthyroidism is not present but intra-adenomatous hypertrophy is found with such

great frequency in glands from patients with no evidence of hyperthyroidism that it can not be considered characteristic When extra-adenomatous hypertrophy is present it is found in localized regions and is not diffuse

**Clinical Considerations.**—The symptoms of hyperthyroidism associated with hyperfunctioning adenomatous goiter (Fig. 112) are those that would be expected to accompany an increase in the basal metabolic rate that is nervousness tremor increased sweating and sense of heat loss of weight and tachycardia In addition when the disease has existed for a long enough time auricular fibrillation is prone to occur Hyperthyroidism may be present for months before the patient is aware that an abnormal state exists and most frequently he consults a physician because of symptoms referable to the cardiac disturbances that accompany the condition Goiter usually has been present for years before symptoms appear the average duration being sixteen years The thyroid gland is enlarged asymmetrically and discrete adenomas are usually palpable Substernal extension of the goiter with tracheal displacement or compression occurs rather frequently The pulse and pulse pressure are increased and the circulation rate is increased Auricular fibrillation occurs in between a fourth and a half of the cases Cardiac decompensation occurs in many cases and may be due to the effect of hyperthyroidism on an already damaged heart or to long continued hyperthyroidism alone In the latter event cardiac decompensation probably occurs through the mechanism of auricular fibrillation or auricular flutter In some instances the cardiac features may so overshadow the clinical picture that the presence of hyperthyroidism may be overlooked and the condition mistaken for one of primary cardiac lesion The basal metabolic rate is usually moderately elevated above the patient's normal level The course of hyperfunctioning adenomatous goiter is usually slowly and steadily progressive If the condition is allowed to progress visceral degenerative changes usually appear If death supervenes it is usually dependent on such degenerative changes particularly of the heart and liver

**Differential Diagnosis.**—Hyperfunctioning adenomatous goiter is distinguished

from exophthalmic goiter by the absence of the characteristics of the latter disease when hyperthyroidism is present. In some mild cases there may be considerable difficulty in making a differential diagnosis. The presence of adenomas in the thyroid gland of a hyperthyroid patient does not suffice to make the diagnosis of hyperfunctioning adenomatous goiter for adenomas are present in the thyroids of from 20 to 30 per cent of the patients with exophthalmic goiter seen at the Mayo Clinic.

Many patients who have essential hyper-tension have increased surface temperature, nervousness, tachycardia and an increased basal metabolic rate. Frequently the basal metabolic rate will fall to a normal level if the patient is kept in bed constantly for a few days. Daily determinations of the metabolic rate are made. Under such circumstances the symptoms and signs suggesting hyperthyroidism usually also disappear.

The manifestations of many patients who have some form of neurosis, neurasthenia or comparable fatigue states simulate the manifestations of mild degrees of hyperthyroidism and the metabolic rate of these patients often is elevated. A most valuable procedure in such cases is the determination of a series of basal metabolic rates on consecutive days. Many neurotic patients after sufficient training in taking the test will exhibit a sharp drop in metabolic rate. Continuous elevation of the basal metabolic rate of a patient whose thyroid gland contains adenomas is best considered as evidence of hyperthyroidism.

**Treatment**—The treatment of a hyperfunctioning adenomatous goiter is partial thyroidectomy. The preoperative administration of iodine does not produce such striking improvement as it does in the patient with exophthalmic goiter but it seems beneficial in some cases. The treatment of complications will be considered under exophthalmic goiter.

The operative procedure indicated for this disease is similar in principle to that for adenoma without hyperthyroidism. However if a patient has a bilateral enlargement with hyperthyroidism and is a poor surgical risk either because of a severe degree of hyperthyroidism or because of the presence of degenerative processes it is sometimes safer

to resect the goiter in two stages that is unilateral resection is followed after the lapse of two or three months by resection of the remaining lobe.

**Prognosis**—The prognosis in cases of hyperfunctioning adenomatous goiter is dependent on the amount of damage that has been sustained at the time the disease is brought under control. If there has been no permanent damage to the viscera complete recovery follows removal of the adenomatous tissue and within two or three weeks after such a procedure the basal metabolic rate usually returns to normal. Even if a patient has a markedly decompensated heart during the course of hyperthyroidism normal function of the circulatory system may be restored following relief of the hyperthyroidism. It is extremely rare for recurrences of hyperthyroidism from adenomatous goiter to occur after removal of all adenomatous tissue from patients who have hyperfunctioning adenomatous goiters.

**Mortality**—The mortality following thyroidectomy for adenomatous goiter with hyperthyroidism has been reported to be approximately 1 to 2 per cent. This mortality is dependent largely on complications of the disease.

### EXOPHTHALMIC GOITER

*(Graves Disease, Basedow's Disease, Primary Hyperthyroidism)*

Exophthalmic goiter is a constitutional disease probably caused by some unknown stimulus which acts on the thyroid gland usually resulting in the production of excessive secretion of thyroxine and associated with certain characteristic phenomena which cannot be reproduced by the administration of thyroid or thyroxine but which may be the result of abnormal secretion from the thyroid gland. The phenomena resulting from the excessive secretion of thyroxine are as in cases of hyperfunctioning adenomatous goiter the manifestations of increased metabolism or oxidative processes, that is an increase in the circulatory rate, increased perspiration, intolerance to heat, increased appetite, loss of weight and weakness.

**Characteristic Phenomena**—In addition to the phenomena previously mentioned as occurring in adenomatous goiter with hyper-

thyroidism patients who have exophthalmic goiter usually present certain characteristic phenomena. Of these the most striking are the ocular disturbances. Exophthalmos is present in nearly half the cases. Retraction of the upper lids, contraction of the facial muscles around the eyes to produce a stare and edema of the lids are seen commonly in various combinations. Weakness of the ocular muscles occurs often, the commonest form being weakness of the elevators of the globe. Marked psychic instability with frequent emotional outbursts usually accompanies the severe untreated forms of the disease and useless purposeful movements are common. The most severe phase of the dis-

ease and the frequent presence of diffuse hypertrophy of these cells, resulting in papillary infoldings into the follicles. The follicular cells are columnar. The colloid is usually thin and stains poorly (Fig. 113 a). As a result of treatment with iodine the following histologic changes occur: (1) flattening of the epithelial cells, (2) increase in the amount and in the staining properties of the colloid, (3) apparent increase in the size of the follicles with diminution in number and size of the papillary infoldings and (4) decrease in vascularity and lymphocytic infiltration (Fig. 113 b). Lymphocytic infiltrations or accumulations of lymphocytes are frequently found throughout the gland.



Fig. 113.—a. Section of an exophthalmic goiter. The patient had taken a small solution of iodine. b. Exophthalmic goiter. The patient had taken a small solution of iodine.

case is the gastrointestinal crisis, which is characterized by vomiting and diarrhea, by intense restlessness and in the late stages by profuse sweating, a gray pallor, falling blood pressure and jaundice. Death may occur although some patients recover from the crisis without significant treatment. Pneumonia frequently develops in the course of the crisis.

**Pathology.**—The thyroid gland is diffusely and symmetrically enlarged. It is firmer to palpation and more friable than the normal gland or colloid goiter. The vascular supply is greatly increased. The characteristic histologic change in exophthalmic goiter is the almost invariable presence of diffuse hypertrophy of the follicular cells

An encapsulated or partially encapsulated nodule or nodules (adenomas) with or without hypertrophy (microadenomas) are found in a small percentage of thyroid glands in Graves disease. Their presence in the diffusely hypertrophic gland of Graves disease is coincidental and should not confuse the pathologist in distinguishing the histologic picture of exophthalmic goiter from that of adenomatous goiter with hyperthyroidism. The presence of diffuse extra-adenomatous hypertrophy throughout the entire gland in exophthalmic goiter and the absence of diffuse extra-adenomatous hypertrophy in adenomatous goiter with hyperthyroidism are the important distinguishing features.



**Clinical Considerations**—The diagnosis of exophthalmic goiter is dependent on recognition of the phenomena noted in the foregoing as being characteristic of the disease. Careful observation of the patient's behavior, motions and facial expression while the history is being taken frequently will give a clue to the diagnosis which might otherwise be missed. Exophthalmic goiter is of more frequent occurrence among females than males, the sex incidence varying in different clinics and in different years. The sex incidence, males to females in the Mayo Clinic has varied from 1:4.69 to 1:1.53 during the past twenty years. Where is the disease most frequently afflicts patients who are between the ages of twenty and forty years, patients may be of any age. Of the historical evidence suggesting exophthalmic goiter, intolerance to heat, persisting and not occurring in flashes, loss of weight during a period when the intake of food is adequate and a fluctuating course with remissions and exacerbations and possibly crises are most important.

On physical examination the skin is found to be hyperemic and abnormally moist. The hands are usually warm. There is usually fine tremor of the extended fingers. The thyroid gland may or may not be considerably enlarged but is usually firm and easily palpable (Fig. 114), especially if palpation is carried out by the method long taught by Plummer. By this method the right lobe of the thyroid gland is felt by the examiner's left hand, the fingers are placed behind the sternomastoid muscle, the thumb in front, and the thumb or fingers of the opposite hand are used to press the structures in the anterior part of the neck into the palpating fingers. The size, contour and consistency of the right lobe can be readily estimated by permitting the lobe to slip through the grasping fingers while the patient swallows. The opposite maneuver is used to examine the left lobe. Bruits over the superior thyroid vessels are often heard and thrills are occasionally felt in the same situations. Muscular weakness is usually a prominent feature in cases of moderate or more than moderate severity and may occasionally be marked in cases of mild degree. It can best be determined by having the patient step up on a high step. The fingernails occasion-

ally undergo a change which if present is nearly pathognomonic of exophthalmic goiter: the distal portion of the nail is separated irregularly from the underlying nail bed and there is a tendency for the nail to turn up at the end. When present this condition is usually bilaterally symmetrical.

Tachycardia is almost constantly present and the tachycardia of exophthalmic goiter is not usually slowed by pressure on the carotid sinus or by holding the breath after deep inspiration. The pulse pressure is considerably elevated, this being a very constant and important finding. The heart is frequently slightly enlarged and a systolic murmur is often heard. The beat of the heart is forceful. Auricular fibrillation occurred in 22 per cent of cases of exoph-

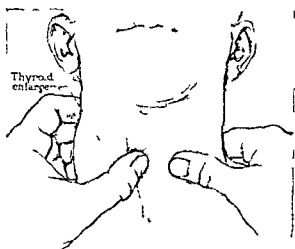


Fig. 114.—Method of palpating the thyroid gland.

thalmic goiter in Williams and Boothby's series. It is transient in many cases, but in others it may be permanent even after the disease has been controlled. Cardiac decompensation occurs most commonly in cases of independent heart disease, but as Kepler and Barnes showed it may occur in cases of uncomplicated exophthalmic goiter. When it does so occur, the mechanism by which decompensation occurs is usually auricular fibrillation or auricular flutter. Other cardiac irregularities are met occasionally in exophthalmic goiter.

The basal metabolic rate is elevated in the majority of cases; it is between +15 and +100 per cent or more.

Leukocytosis often is present, the total leukocyte count is normal. This finding is

not sufficiently constant or marked to be diagnostic

The concentration of blood cholesterol is lowered in cases of exophthalmic goiter. Perkin and Cattell expressed the opinion that the total concentration of iodine in the blood which usually is increased in hyperthyroidism is a better criterion in the differential diagnosis of thyrotoxicosis than the basal metabolic rate. Perkin and Lacey found that elevation of the concentration of iodine in the blood becomes less with increasing duration of the disease until after a year the concentration of iodine tends to be normal.

**Recognition of Exophthalmic Goiter**—Among recently graduated physicians the recognition of exophthalmic goiter is too frequently dependent on the classical signs and symptoms of the disease that is tremor, tachycardia, goiter and exophthalmos. Sometimes these are either absent or so slight that they are not noticed readily and the diagnosis of exophthalmic goiter is not even considered. Thus many patients who have mild exophthalmic goiter are suspected because of loss of weight, weakness and diarrhea, for example, of having carcinoma of the digestive tract and many are considered as primarily suffering from cardiac disease because of symptoms referable to the heart. Among the signs or symptoms that should lead to a suspicion of hyperthyroidism are unexplained loss of weight especially suggestive if associated with a normal or excessive appetite, an increased pulse, pressure, weakness of the quadriceps muscles and intolerance to heat with increased sweating and a warm moist skin. The presence of auricular fibrillation always demands consideration of hyperthyroidism. Obviously, mild hyperthyroidism will be recognized only if the condition is kept in mind and its frequency is sufficiently great to justify bearing it constantly in mind.

**Course of the Disease**—If uncontrolled the course of exophthalmic goiter usually tends to be irregular waves of progression alternating with remissions which may be nearly or quite complete. Undoubtedly the disease would subside spontaneously in many instances if it were not interrupted by treatment. However it is impossible to determine at any point in the disease what the

future course is to be. Occasionally mild exophthalmic goiter may exist for many years without causing intolerable disability. On the other hand in fulminating cases the patients may become extremely ill within a few weeks of the onset of the disease. Patients who have had the disease for years should be assumed to have degenerative visceral changes.

**Differential Diagnosis**—In general difficulties in diagnosis lie chiefly in the same groups of cases as were discussed under adenomatous goiter with hyperthyroidism and the problems often may be solved by the same means.

There is in addition one valuable diagnostic procedure which may be used in exophthalmic goiter. This is determination of the effect of iodine. Seven to ten days after beginning the oral administration of 10 minims of compound solution of iodine three times daily to a patient who has exophthalmic goiter there occurs a marked change in the patient's physiologic status. The stare diminishes, the movements characteristic of the disease disappear or diminish, the psychic status becomes normal or nearly so and there is usually a drop in the basal metabolic rate. This procedure may therefore be used as a diagnostic measure with a considerable degree of success provided sufficiently accurate observations of the patient's physiologic status and basal metabolic rates are made before instituting the administration of iodine.

**Treatment**—Until the cause of the disease is discovered and a specific therapeutic agent is found to combat the cause it is apparent that in the light of present knowledge the only rational method of attack consists in the employment of measures to reduce the activity of the thyroid gland supplemented by supportive and protective measures designed to eliminate such predisposing etiologic factors as overwork, mental and emotional stresses, infections and the like.

The measures most commonly employed in the endeavor to reduce the activity of exophthalmic goiter are (1) administration of iodine, (2) irradiation and (3) operation (Fig. 115) and (4) to these must be added treatment with thiouracil. Through the observations of many investigators notably

Marine, Broders, Rienhoff, Cattell and others, it has been demonstrated that marked involutional changes occur in the hyperplastic and hypertrophic gland of exophthalmic goiter in the great majority of instances following the administration of iodine for a period of ten days or longer. Concomitant with these structural changes in the gland, there is usually diminution in the severity of the disease, as evidenced by amelioration of all the symptoms and reduction in the basal metabolic rate. Occasionally, if the patient has a very small goiter and is seen early in the course of the disease, his condition may be completely and permanently controlled by the administration of iodine. However, clinical experience has

The Mackenzies and Astwood, by studying the goitrogenic effects of various drugs, confirmed the finding that depression of thyroid function and hypertrophy of thyroid parenchyma followed administration of sulfonamides and drugs related to thiourea. Astwood treated exophthalmic goiter with thiourea and thiouracil and found that the basal metabolic rate fell to normal and that the symptoms and signs of the disease disappeared. This brilliant work constitutes an important advance in the study of thyroid function and provides a method of medical treatment of hyperthyroidism which may become extremely important. Some undesirable reactions have occurred after the use of thiouracil. Agranulocytosis, febrile reac-



Fig. 115.—A patient with an exophthalmic goiter. a, Before operation, b, after operation.

demonstrated that the maximal effect of iodine is commonly obtained within from seven to twenty days, and after this there is little hope that prolonged treatment will control the disease in the vast majority of cases.

Employment of irradiation in the treatment of exophthalmic goiter is based on the conception that the hypertrophic parenchymatous cells of the thyroid gland are peculiarly radio-sensitive, while the normal cells are radioresistant. Although experimental proof is lacking that involutional changes occur in the gland after irradiation, many advocates of this form of treatment have claimed good results from its employment. With few exceptions these claims have not been supported by sufficient factual data.

tions with or without a skin rash, and transient edema with elevation of the plasma chlorides and depression of the carbon dioxide-combining power of the plasma have occurred in some cases. The reported reactions have rarely resulted seriously, but obviously a drug which may produce such reactions must be carefully studied in a large series of cases before it can be widely used with safety. At the present time, patients taking thiouracil should be kept under careful and constant observation during the period of treatment. The ultimate place of this drug in the treatment of thyrotoxicosis has not been established definitely, but it seems likely that one important field of usefulness will be the preparation for surgical treatment of those patients who, because of

the severity of hyperthyroidism are poor surgical risks. When thiouracil is used to prepare patients for thyroidectomy it is desirable also to administer iodine for some days immediately before the operation.

Today the opinion prevails among those most experienced with the disease and its management that subtotal thyroidectomy is the treatment of choice for it most rapidly, most certainly and most safely restores the patient to a state of economic efficiency and involves least likelihood of relapse. Space permits only a limited discussion of the principles of management which can best be considered under three headings: (1) preoperative preparation, (2) criteria of operability and (3) operative principles.

**Preoperative Treatment**—In 1922 H. S. Plummer established the value of iodine in the treatment of exophthalmic goiter. In the uncomplicated case of exophthalmic goiter of moderate severity administration of 10 minims of compound solution of iodine three times daily for a period of from eight to ten days will bring about sufficient improvement to allow partial thyroidectomy to be performed with minimal risk and to abolish all fear of postoperative crisis. Patients who have exophthalmic goiter of more than average severity should be given iodine for longer periods and it has seemed advisable to hold those patients who have begun treatment during a crisis for a period of at least a few weeks on a regimen of iodine before consideration of operation in order that the profound physiologic disturbances incident to the crisis may have an opportunity to correct themselves during the period of general improvement. Cessation of treatment with iodine if a patient has exophthalmic goiter may result in the rapid development of a crisis. Although the basal metabolic rate usually drops during the period of administration of iodine this is not essential to improvement of the patient's physiologic status. Thiouracil or some other related drug may play an important part in the preoperative treatment in certain cases.

In order to maintain nutrition and to overcome the depletion of glycogen a liberal diet is advisable. Boothby and Sandiford have shown that such a diet will also keep the patient who has exophthalmic goiter in nitrogen balance. Often 2000 calories a day

are taken readily. The intake of fluid is also kept at a high level. During the period of preparation for operation it is important that the patient obtain adequate rest but he should not be continuously confined to bed. Evidence is accumulating which suggests that because of relative vitamin deficiency especially of vitamins A and B the addition of large amounts of these substances to the diet may be of value in some cases.

**Complications Sometimes Encountered in the Preoperative Treatment**—When exophthalmic goiter is complicated by other diseases the treatment of which is surgical treatment of the goiter usually should take precedence. Certain conditions which usually are treated medically also require attention.

1 **Diabetes**—Fitz, Wilder and others have demonstrated the marked increase in severity of diabetes that may occur with the development of hyperthyroidism. Usually there is a considerable increase in the amount of insulin required. During the period of preoperative preparation it seems desirable from the standpoint of general nutrition as well as for restitution of depleted stores of glycogen and because of possible damage to the liver to give the patient who has diabetes and exophthalmic goiter a diet containing from 75 to 100 per cent more calories than the patient's basal diet and to give adequate amounts of insulin to control the glycosuria.

2 **Cardiac Decompensation**—Because Plummer showed that digitalis might have deleterious effects on a hyperthyroid patient this drug should be given only in small dose and with great caution. Fortunately other methods of treatment have proved so successful in relieving these patients of cardiac decompensation that digitalis is needed only rarely. In many cases rest in bed and the administration of iodine will result in rapid improvement in the cardiac condition and further treatment may not be necessary. When this treatment is not sufficient the mercurial diuretics usually will suffice to rid the patient of edema. Control of hyperthyroidism by thiouracil may result in marked improvement in the circulatory system. This drug may be of especial value in the preoperative treatment of such patients.

**Criteria of Operability**—When is it safe to operate and what procedure should be employed? On the proper solution of these two questions rests to a large degree the success of treatment. Obviously hard and fast rules of treatment cannot be applicable to all patients and each case must be judged by itself. In the final analysis accuracy of estimating the risk of operation to a patient who has an exophthalmic goiter is largely dependent on the experience of the surgeon. Always he should be cognizant of the fact that in an operation on a patient who has exophthalmic goiter there are three additional risks which are absent or uncommon if the patient has goiter unassociated with hyperthyroidism. These dangers are (1) the postoperative development of an acute hyperthyroid reaction especially likely to occur if the patient has severe hyperthyroidism, (2) the development of pulmonary infections commonly seen if the patient is markedly debilitated consequent to a recent crisis of the disease or to long continued hyperthyroidism and (3) hepatic insufficiency consequent to long continued hyperthyroidism. By adequate preoperative management these complications usually can be avoided.

In an uncomplicated case of exophthalmic goiter of average severity the administration of iodine for eight to ten days is usually sufficient preparation. The time necessary for iodine treatment is longer than this in children and in adults who have been recently in the crisis of the disease. It is desirable that the patient be gaining in weight and that the basal metabolic rate be dropping at the time of operation but in some instances these improvements cannot be achieved and operation will then entail a greater than normal risk. If the excessive nervousness and stimulation of the patient have subsided on preoperative treatment there is little or no risk of postoperative crisis. In cases in which there are complications or serious damage to vital organs preoperative treatment may be prolonged considerably to allow recovery from hepatic or cardiac damage. Only under extreme conditions need the preoperative treatment require more than three weeks.

However a small percentage of patients do not respond sufficiently to preoperative

treatment to become good risks and substitution of a lesser operative procedure such as ligation of the superior thyroid vessels or partial lobectomy at a diminished hazard may so improve the patient's condition that later subtotal thyroidectomy may be performed safely. Thoroughly with the subsequent addition of iodine may afford sufficiently effective preparation so that ligation of vessels or hemithyroidectomy may become unnecessary in such cases.

**Operative Principles**—The basic principles of the operation of partial thyroidectomy consist of (1) removal of a sufficient amount of the abnormal thyroid gland (commonly from 70 to 90 per cent of the whole) (2) preservation of thyroid tissue sufficient to maintain adequate function (usually equivalent to from one sixth to one third of a lobe of normal size) (3) control of bleeding (4) avoidance of sepsis and injury to adjacent structures and (5) attainment of a satisfactory cosmetic effect. The most common technical complications of the operation are secondary bleeding and injury of a recurrent laryngeal nerve. Fortunately both errors are avoidable provided the surgeon is constantly on the alert and plans the operative technique so as to afford maximal protection against their occurrence. If the posteromedial portion of the lobe is preserved without exposure of the lateral wall of the trachea this mass of tissue will serve as a protective barrier between the operative field and the nerve and seldom will injury of the nerve occur (Fig 186). Unless the operation consists of a needlessly radical removal of most of the thyroid tissue the development of postoperative parathyroid tetany is an exceedingly rare complication of primary operation on the thyroid gland. It is practically limited to operations for recurrent goiter. In these cases the threshold of safety is often reduced because of removal of one or more parathyroid glands in the first operation. In an operation on a patient who has a recurrent goiter it is wise for the surgeon to assume that all but one of the parathyroid glands were removed at the first operation and accordingly to preserve a generous portion of the posterior and lateral capsules to avoid injury to the remaining glandules.

**Prognosis**—The most important factor

which influences the prognosis in exophthalmic goiter operations is the presence of secondary complications of the disease notably the degenerative changes of the various organs such as the heart liver and muscles. Development of these changes is largely dependent on the duration and intensity of the disease. Following adequate preoperative preparation with iodine an operative mortality of 1 per cent or lower has been reported by several authors. Following subtotal thyroidectomy the basal metabolic rate ordinarily drops to the normal level within from two to four weeks with a associated abatement of symptoms. By far the greater majority of these patients have returned to normal health within a period of from six to twelve months. If the disease is

wound is especially prone to occur after operations for the resection of the thyroid gland. Two facts in particular account for the tendency to bleed: (1) the extreme vascularity of the gland and (2) the fact that the remnant of the resected gland cannot be immobilized because of its attachment to the trachea. The seriousness of this complication usually is due not to the volume of blood lost but to suffocation and impairment of cardiac action resulting from compression of structures in the neck and upper mediastinum.

Bleeding commonly occurs within twelve hours (at most twenty-four hours) after operation and is manifested by swelling of the neck causing the patient to complain of tightness of the bandage, the development



Fig. 116—Cross section of (a) an exophthalmic goiter and (a') an adenomatous goiter showing the position and relative amount of the thyroid tissue preserved (shaded areas) in a subtotal thyroidectomy. b and b' show the reconstruction of the remnants of the glands into manure-like blocks.

completely and permanently controlled early in its course disability is not likely to ensue. In a small number, probably less than 5 per cent of cases in which partial thyroidectomy has been performed, either manifestations of the disease are incompletely controlled or at some later date the symptoms and signs of exophthalmic goiter return.

**Treatment of Complications after Thyroidectomy.**—The complications after partial thyroidectomy, the results of a technical error, are limited for the most part to three: that is, postoperative hemorrhage, injury to the recurrent laryngeal nerve or nerves, and parathyroid insufficiency.

**1. Postoperative Hemorrhage.**—Unless meticulous care is observed in obtaining accurate hemostasis, serious bleeding from the

of respiratory difficulty or stridor, a change in the voice (guttural) and cyanosis. After removal of the bandage the swollen neck usually makes the diagnosis obvious, but occasionally among patients who have heavy cervical muscles there may be no apparent swelling. However, the diagnosis should be suspected because of the increased firmness when the neck is palpated. Whenever this complication is suspected the patient should be returned immediately to the operating room, the wound reopened, the clot evacuated and the bleeding vessels ligated. If general anesthesia is contemplated the anesthetic agent should not be administered until after removal of the obstructing clots.

**2. Respiratory Stridor.**—Among the causes of this complication the following may be

listed paralysis of one or both vocal cords hemorrhage into the wound tetany collapse of the trachea and edema of the glottis. However by far the most common is paralysis of the vocal cords incident to operative trauma of the recurrent laryngeal nerve. Injury to the nerve usually results in the fixation of the homolateral cord in the midline position thus narrowing the rima glottidis by half. In most instances this complication is unattended by serious stridor but in some cases associated with marked edema of the glottis serious respiratory difficulty may develop. Bilateral injury of recurrent nerves with the fixation of both cords in the midline position always is attended by serious stridor and usually requires tracheotomy for its relief. In rare instances gradual paralysis of both vocal cords may develop twenty-four to forty-eight hours after partial thyroidectomy when no injury has occurred directly to the recurrent laryngeal nerves and when both cords have moved normally after completion of the operation. This is a temporary paresis persisting for two to five days and probably results from edema and swelling of the nerves. Early administration of 50 to 60 per cent oxygen or of 90 to 40 per cent oxygen in helium may avert the necessity of tracheotomy. However if this does not relieve the labored respiratory efforts promptly, tracheotomy should not be delayed.

For the relief of partial respiratory obstruction the result of bilateral paralysis of the vocal cord among patients who have survived the operation of thyroidectomy King has devised an operation to widen the space between the two fixed vocal cords by the dislocation and lateral fixation of one of the arytenoid cartilages. This has proved to be successful in relief of dyspnea with out impairment of the speaking voice.

**3 Parathyroid Insufficiency**—This is fortunately a rare complication but one which is frequently unrecognized unless looked for. Numbness of face or hands is usually the earliest symptom. Difficulty in focusing the eyes generalized weakness or respiratory stridor may be the only presenting symptom the latter occurring most frequently when one vocal cord is paralyzed. Carpopedal spasm or generalized convul-

sions usually occur only after the condition has existed for days. Chvostek's and Trousseau's signs are nearly pathognomonic. The concentration of calcium in the blood is lowered and that of inorganic phosphates is increased. Prompt and persistent treatment preferably with calcium lactate in 4 Gm doses dissolved in very hot water and administered orally or in case of necessity with solution of calcium gluconate or chloride administered intravenously will give rapid control. In most cases the condition is temporary. However when it is prolonged or permanent the use of dihydrotachysterol and calcium will control even the most severe parathyroid insufficiency. Dihydrotachysterol (Holtz Gissel and Rossmann) usually is given in doses of 2 to 3 cc orally weekly. Supplementing it with calcium lactate or gluconate reduces the amount of dihydrotachysterol needed. Determination of the concentration of calcium in the blood should be made occasionally as toxic effects and hypercalcemia may occur in the treatment of some persons with very small doses of dihydrotachysterol. Cataracts and symmetrical cerebral calcifications may occur in cases of parathyroid insufficiency of long duration in which treatment has not been given. Parathyroid hormone also may be used in the treatment of this condition.

**Recurrent Exophthalmic Goiter**—Exophthalmic goiter recurs or persists probably in those cases in which the cause of the disease is present with greatest intensity or persistence. The amount of thyroid tissue left after adequate resection is not the major factor which determines the recurrence of the disease. Enlargement of the thyroid may or may not occur. The factors which determine the enlargement of the gland are no more known than is the cause of the disease. All the manifestations of the disease may appear during a recurrence and the diagnostic problems are the same as they are in cases of primary exophthalmic goiter in which operation has not been performed. The treatment also is identical with the treatment of patients who have not been operated on except that in an appreciable number of cases satisfactory control can be achieved by the administration of iodine alone. Such control has been reported from the Mayo Clinic in 25 per cent of a series

of 468 cases in which exophthalmic goiter recurred. Recurrences have occurred less frequently in our cases since we have routinely given iodine constantly for a year after thyroidectomy.

Marked progressive exophthalmos with chemosis occurs very rarely among patients who have undergone partial thyroidectomy for exophthalmic goiter. According to Naffziger this condition is attributable to enormous swelling and degeneration of the intra-orbital muscles and relief is obtained by an operation for decompression of the orbit. Prolonged administration of iodine and of desiccated thyroid in those cases in which the basal metabolic rate is lowered seems to have been of value in some instances. Roentgen treatments to the orbits as described by Ruedemann, Ginsburg and others have been followed by subsidence of edema and exophthalmos in some cases. More patients must be treated before definite evaluation of any method of treatment can be made as in some instances rapid spontaneous remission may occur.

### THYROIDITIS

In this discussion the term 'thyroiditis' is used to designate an inflammatory process involving the thyroid gland irrespective of the status of the gland before the onset of the inflammatory process.

**Acute Thyroiditis.**—Acute thyroiditis is a relatively rare condition and may run a self-limited course of from five to ten days and then may completely subside or suppuration and formation of abscess may ensue. Commonly the process is limited to one lobe but occasionally it may spread to involve the entire gland. In addition to increased vascularity and infiltration of the tissues by leukocytes and lymphocytes the histopathologic changes include hypertrophy and hyperplasia of the epithelium, the presence of foreign body giant cells and small follicular lumens containing a thin poorly staining colloid and desquamated epithelial cells.

**Symptoms.**—The disease is commonly ushered in by chills followed by high fever and leukocytosis. In the milder forms however the entire course may be afebrile. Pain in the neck, usually not localized to the region of the thyroid gland, is diffuse not only

throughout the cervical region but often is referred by way of the cervical nerves to the ear and occipital region. Pain is increased by movements of the head and on swallowing. The affected lobe of the gland enlarges is exquisitely tender and presents on palpation a firm or indurated consistency. Hoarseness occasionally is present and is attributable either to paralysis of a recurrent laryngeal nerve or to edema of the larynx. Dyspnea and cough may result from pressure of the swollen gland on the trachea. The disease not infrequently is associated with mild hyperthyroidism which may disappear with subsidence of the inflammation or may persist for a time afterward. In cases in which suppuration occurs and surgical drainage is not instituted the abscess may point in any direction. Usually however the pus burrows anteriorly through the skin but cases have been reported in which the abscess ruptured into the trachea or into the mediastinum with fatal outcome.

**Prognosis.**—In most cases of the non-suppurative form of thyroiditis the inflammation subsides spontaneously with complete resolution. In some cases the process may pass into chronic thyroiditis. The mortality is largely dependent on the primary or antecedent infectious process. Myxedema as a sequel of acute thyroiditis has been reported but is uncommon.

**Treatment.**—Application of heat to the cervical region will lessen pain and will aid in promoting resolution of the inflammatory process. Adequate surgical drainage should be instituted as soon as the formation of an abscess is suspected.

**Chronic Non Specific Thyroiditis.**—A relatively large number of goitrous glands are surgically resected which on histologic examination show unmistakable evidence of chronic inflammation of varying gradations. The cause of the inflammatory reaction in the gland is not known. The inflammatory changes are usually diffuse involving both lobes and are manifested chiefly by infiltration of tissues by lymphocytes at times occurring in clumps of follicles with typical germ centers by the presence of plasma cells and by proliferation of the connective tissue stroma. Degeneration and desquamation of the epithelial elements may or may not be present. The presence of these changes in



the goitrous gland is of especial clinical importance because of the bearing it has on the ultimate prognosis following surgical resection of a goiter, especially an exophthalmic goiter. Myxedema as a sequela of subtotal thyroidectomy is practically confined to the cases in which the goitrous gland is also associated with thyroiditis. The more marked these changes are, the greater the likelihood of the development of myxedema. When these changes are recognized in the course of an operation, the risk of subsequent development of myxedema can be minimized by preserving more gland tissue than is normally preserved.

There are two forms of primary chronic non-specific thyroiditis of obscure origin

the patients, and the condition accounts for about 0.1 or 0.2 per cent of all cases of goiter in which operation has been performed in the Mayo Clinic. The disease is usually slow in its onset, which is marked by gradual enlargement of the thyroid gland and commonly by increasing dyspnea, which at times is alarming. As the disease progresses, the trachea and larynx become compressed, and edema of the larynx develops. Cases of any considerable duration are associated with evidence of diminished thyroid function, rarely, however, to the extent of the development of myxedema.

The gland is bilaterally enlarged, pre-ent-ing on palpation a very firm or hard tumor, which may be partially fixed to the sur-



Fig. 117—*a*, Diffuse chronic thyroiditis (woody type); *b*, diffuse carcinoma of the thyroid gland showing cord-like arrangement

which are commonly considered to be pathologic entities rather than advanced stages of the inflammatory process above described: (1) woody thyroiditis or Riedel's struma and (2) struma lymphomatosa (Hashimoto). Both of these processes may be superimposed on a previously goitrous gland, but more often on a non-goitrous gland.

**Woody Thyroiditis or Riedel's "Eisenharte Strumitis"**—This is a comparatively rare disease of the thyroid gland. Pathologically, chronic progressive sclerosis of extremely dense character involves not only the entire gland but frequently the adjacent structures as well (Fig. 117, *a*). Its occurrence is rare, females predominate among

rounding structures. Because of the infiltrating nature of the process, the borders of the tumor are often completely obliterated, however, unless the disease is superimposed on a goitrous gland, its surface usually remains smooth rather than nodular. It can be readily appreciated that the resemblance of this disease to advanced cancer of the thyroid gland may be so close that the two are clinically indistinguishable. The bilateral involvement, the smooth surface, the stony hardness and the absence of enlarged cervical nodes are more suggestive of Riedel's struma than of cancer, but commonly removal of a portion of the tumor for microscopic study offers the only means of making a definite diagnosis.

In cases in which treatment has not been given the process is rarely regressive usually progressive and occasionally stationary Following partial resection of the gland there is commonly striking regression with relief of all symptoms of pressure

Surgical exploration of the tumor is indicated in practically all cases for the dual purpose of establishing the diagnosis and of relieving or preventing tracheal compression In most instances the operation indicated is bilateral partial resection of the thyroid gland with removal of the isthmus a generous portion of each lobe is preserved In those cases in which the process has infiltrated into surrounding structures the hazard of resecting a lateral lobe may be prohibitive In such instances the trachea may be decompressed by removal of the isthmus and this will be accompanied by relief of dyspnea and sometimes will be followed by marked decrease in the size of the tumor In about 50 per cent of the cases in which operation was performed at the Mayo Clinic hypothyroidism or myxedema subsequently developed

*Struma Lymphomatosa (Hashimoto) or Lymphadenoid Goiter (Williamson and Pearce)*—This is a comparatively rare disease of unknown cause characterized by moderate enlargement of the thyroid gland the result of abundant and diffuse lymphoid infiltration which ultimately destroys or seriously impairs its function Whether or not lymphoid infiltration is an inflammatory process is not definitely known The condition is apparently analogous to a rare disease of the salivary and lacrimal glands described by Mikulicz in which these glands enlarge as a result of diffuse lymphoid infiltration It is commonly mistaken for colloid or adenomatous goiter and occasionally for carcinoma As the disease progresses myxedema is prone to develop whether the thyroid is resected or not Roentgen treatment has given good results in some hands Surgical treatment may be advisable to exclude the possibility of cancer or to relieve symptoms of pressure

*Specific or Granulomatous Thyroiditis*—Cases of syphilis and actinomycosis of the thyroid gland have been reported but they are exceedingly rare Only one form will be considered at any considerable length

*Tuberculous Thyroiditis*—Proved tuberculosis of the thyroid gland is rarely seen In generalized military tuberculosis tubercles are occasionally found in the thyroid gland

Microscopic lesions resembling tubercles and containing giant cells are frequently found in the thyroid glands of patients presenting the clinical picture of exophthalmic goiter and occasionally in cases of nodular goiter In most of these cases *Mycobacterium tuberculosis* cannot be demonstrated in the tubercles or by inoculation of guinea pigs The giant cells in some instances have been shown to include bits of colloid The patients are usually free from demonstrable tuberculosis elsewhere The immediate and end results of subtotal thyroidectomy in these cases are as satisfactory as they are in cases of comparable goitrous lesions in which microscopic examination does not suggest tuberculosis It seems probable that most patients in this category do not have tuberculosis of the thyroid gland

### MYXEDEMA

Myxedema is a constitutional disease resulting from partial or complete destruction of the thyroid gland and characterized by a low basal metabolic rate and edema of the tissues of the body This may occur spontaneously commonly as a result of an inflammatory process of low grade or the loss of function may follow operative removal of the gland

*Clinical Consideration*—The most characteristic changes in myxedema are produced by edema The typical facial appearance results from edema of the subcutaneous tissues with resultant loss of expression The voice is coarse and low pitched because of edema of the vocal cords The skin is dry and scaly Physical and mental activities are slowed Recovery of the peripheral tendon reflexes is slowed (Chancey)

The basal metabolic rate is low and the concentration of blood cholesterol is elevated Slight enlargement of the heart occurs frequently The T waves of the electrocardiogram are usually flattened or inverted and rarely other abnormalities are present such as prolongation of the P R interval Anemia is a frequent accompaniment of long standing myxedema The color in

dev is high and macrocytosis may be present. The gastric content frequently contains no free hydrochloric acid.

**Treatment**—The fundamental principle underlying the treatment of myxedema is deliverance to the body of a constant supply of thyroxin in quantities sufficient to maintain the basal metabolic rate at the individual normal level. This program necessitates administration of thyroid or thyroxin at regular intervals preferably daily and in constant amounts.

Not all patients who have low basal metabolic rates after thyroidectomy actually have thyroid deficiency. There are many people who normally have basal metabolic rates lower than the average and who do not give evidence of any of the changes which invariably appear in those persons known to be deficient in thyroid. The patients who have low basal metabolic rates without evidence of myxedema are often asthenic and easily fatigable and ordinarily present complaints similar to those heard from patients who have so-called chronic nervous exhaustion.

### CRETINISM

Cretinism occurs sporadically in this country. Patients afflicted with cretinism having been deficient in thyroid from birth or during intrauterine life ordinarily sustain injury to the central nervous system which is not overcome by administration of thyroid even though this may be instituted at an early age. The symptoms and signs are those of myxedema with the additional disturbances of development dependent on an insufficiency of thyroxine during the formative years of life.

### MALIGNANT DYSPLASIA

The reported incidence of malignant disease of the thyroid gland varies in different communities; it is higher in goitrous regions than in non goitrous regions. Wegelin gave the astonishingly high incidence in Berne of carcinoma of the thyroid gland in one in every 96 postmortem examinations whereas in Berlin it was one in 1033 and in the United States one in 925. Among patients operated on for goiter the frequency of carcinoma of the thyroid gland as compared with benign nodular goiter is about 2.5 to

3 per cent while as compared with all benign goiters the average is about 1 per cent. The disease is more frequent among females in the proportion of two to one. The age incidence of the disease corresponds closely with that of malignant disease of other organs. 69 per cent of the patients are within the fourth, fifth and sixth decades of life. It is worthy of emphasis that about 3 per cent of the patients are in the first and second decades of life. From the histories of patients who have malignant disease of the thyroid gland evidence appears conclusive that in a large percentage of the cases the malignant process develops on the basis of a pre-existing benign goiter. Occasionally, however, it develops in a non goitrous gland and very rarely in the hypertrophic gland of exophthalmic goiter.

There is widespread variation in the structural and biologic characteristics of malignant thyroid tumors and because of a close although not constant relationship between the clinical course of the disease and the pathologic features of the growth a classification of the malignant tumors based on this relationship is desirable. The following clinicopathologic classification of primary malignant tumors of the thyroid gland has proved satisfactory.

- 1 Papillary adenocarcinoma
- 2 Adenocarcinoma in a fetal adenoma (malignant adenoma or struma proliferans)
- 3 Diffuse adenocarcinoma
- 4 Epithelioma
- 5 Sarcoma

Tumors of epithelial origin constitute an overwhelming proportion of the malignant diseases of the thyroid gland about 98 per cent. Of the latter about 70 per cent are of the relatively low grades of malignancy (1 and 2). The diagnosis of malignant disease of the thyroid gland just like that of malignant disease elsewhere in the body is based on the presence of anaplasia or cellular dedifferentiation.

**The Various Types of Malignant Growth**—These will be taken up according to the classification just given.

**Papillary Adenocarcinoma**—Commonly this tumor has its origin in a pre-existing benign tumor but occasionally it is seen to arise in a non goitrous gland. It is readily

distinguishable by its papilliferous structure. While this type of thyroid carcinoma is always of a low grade of malignancy, grade 1 or 2, it has a marked tendency to invade the lymph spaces and to spread to involve the cervical lymph nodes. The growth is very slowly progressive and in inoperable cases it usually will remain localized in the cervical region for many years. In a series of 267 cases of malignant disease of the thyroid gland reported from the Mayo Clinic this type of tumor constituted 30 per cent.

Occasionally papillary adenocarcinomas of the thyroid structure occur as single or multiple nodules in the neck separated from the thyroid gland. They are found lateral to the gland above the superior pole along the course of the deep jugular vein or in the posterior cervical triangle. Usually they are partially cystic and of a dark color. The origin of these tumors is usually attributed to misplaced rests of thyroid tissue; the remnant of the lateral primordial structure. There is more evidence, however, to indicate that they are secondary to a primary

spindle-shaped or giant cells may simulate the picture of sarcoma. Metastasis occurs by way of the lymph or blood stream or both. The route fulminating malignant epithelial growths of the thyroid gland are represented by this type. Diffuse adenocarcinoma represented 27 per cent of the previously mentioned series.

**Squamous Epithelioma**—These tumors of the thyroid gland may arise directly by metaplasia of its epithelium or secondarily from extension of epithelioma of the esophagus, trachea or thyroglossal duct. This type of growth is extremely rare and exceedingly malignant. The prognosis is grave.

**Sarcoma**—This is of very rare occurrence in the thyroid gland. It constitutes probably not more than 1 per cent of all malignant growths of this structure.

**Metastasis**—Distant disseminations of malignant epithelial growths of the thyroid gland may occur as single or multiple nodules involving different organs. The most common sites are the regional lymph nodes, lungs, mediastinum and bones.

**Clinical Considerations of Malignant Disease**—Symptoms on which the diagnosis can be made definitely are usually not present until the malignant tumor has perforated the capsule of the gland and has invaded the surrounding structures. At this stage there is a hard, irregular, nodular tumor, often unilateral and fixed in its bed, with or without cervical involvement frequently associated with hoarseness and paralysis of a vocal cord. Horner's syndrome, a sense of pressure or pain in the neck, pain along the distribution of cervical nerves, dysphagia, dyspnea and loss of weight. Then and not until then can the diagnosis be made with any degree of accuracy. Unfortunately when the diagnosis is obvious the growth may have advanced beyond the reach of the surgeon.

Prior to the time when the malignant process has invaded contiguous structures, features which are suggestive of the diagnosis may or may not be present. The sudden development of a tumor in a non-gonitrous gland or rapid growth of an adenoma of long standing always should be looked on with serious misgivings. Unusual firmness of the tumor should arouse further suspicion. Evidence of early invasion sometimes can

be obtained by detecting diminished mobility of the tumor and by the development of hoarseness associated with paralysis of a vocal cord. Estimation of the basal metabolic rate is of no value as an aid in distinguishing benign from malignant tumors since there is no constancy of the basal metabolic rate in either condition. Unfortunately in many instances there are no features of early malignant tumors by which they may be distinguished clinically from benign tumors.

**Treatment**—The principles of treatment of malignant disease of the thyroid gland should be considered according to the stage of development of the disease that is consideration should be given to whether the case is operable or inoperable and to whether the growth is a benign adenoma that may be a precursor of a malignant tumor. Operability depends on the extent of local invasion of the primary lesion and on absence of distant metastasis. Tumors which are completely fixed to all the contiguous structures should not be operated on for the prospects of benefiting the patient under these circumstances are not commensurate with the hazard involved in extirpating the growth. However if mobility is merely restricted thus suggesting perforation at only one point operation should be undertaken for not infrequently the tumor can be removed in its entirety. When the tumor is partially fixed and the cervical nodes are involved extensive surgical removal of the primary growth together with dissection of the affected cervical nodes is often justifiable if the growth is of the papillary form whereas the operation is only futile if the growth is of one of the more highly malignant forms.

The treatment indicated for encapsulated malignant growths which may be represented by any one of the three common epithelial neoplasms is wide surgical removal supplemented by postoperative irradiation by radium and roentgen rays. This form of treatment will produce satisfactory results as the more radical operation of total thyroidectomy. Since malignant growths of the thyroid gland are for the most part radiosensitive occasionally surprisingly good results have been obtained

in inoperable cases by treatment with radium and roentgen rays.

**Adenoma as a Precursor of Malignant Growths**—From the fact that a large percentage of all malignant tumors of the thyroid gland develop in a pre-existing benign nodular goiter, it is obvious that retention of a nodular goiter subjects the patient to a certain potential risk of developing malignant growth. This risk does not exceed 1 to 2 per cent but when added to the other potential risks of a neglected nodular goiter that is development of hyperthyroidism and development of symptoms of pressure consequent to growth of the goiter it is apparent that the danger of retaining the goiter is probably greater than the danger incident to its surgical removal.

**Prognosis**—Because of the difficulty of distinguishing by clinical methods a benign from a malignant tumor of the thyroid gland about 50 per cent of the patients who have carcinoma of the thyroid gland have an inoperable condition when they present themselves for treatment. Following irradiation a small percentage of these patients will live for five years or longer, for the most part these patients have a low grade papillary form of the disease. The average length of life following treatment is about twenty-one months. In operable cases the most important factors which influence prognosis are the type and grade of the neoplasm. In order from least malignant to most malignant tumors of the thyroid gland of malignant types may be named as follows: papillary adenocarcinoma, malignant adenoma, diffuse adenocarcinoma and sarcoma and squamous cell epithelioma. Almost without exception patients who have sarcoma or squamous cell epithelioma die within a year of operation whereas nearly 50 per cent of the patients who have other forms of neoplasm live five years or longer following surgical removal of the tumor.

#### ANOMALIES

Wegelin has classified development of anomalies of the thyroid gland in six groups: (1) complete aplasia (sporadic cretinism), (2) failure of descent of the thyroid anlage with heterotopia of the thyroid tissue at the root of the tongue, (3) partial aplasia

(4) simple hypoplasia (5) retention of the thyroglossal duct and (6) accessory glands as a result of aberrant thyroid tissue (lateral inferior and intratracheal forms)

**Lingual Thyroid or Lingual Goiter.**—When heterotopic thyroid tissue is present at the base of the tongue near the foramen caecum it is commonly referred to as a lingual thyroid or lingual goiter. This tumor may constitute all the thyroid tissue possessed by the individual or it may occur in association with a normally or imperfectly developed cervical thyroid gland. As a rule the condition is not recognized until adult life when growth of the tissue becomes manifest by the presence of a swelling at the root of the tongue. The symptoms of cough, dyspnea and dysphagia are dependent on the size of the tumor, which some times may reach that of a walnut or larger. Ulceration of the tumor is then not uncommon, resulting in alarming hemorrhage.

**Treatment.**—Since the lingual thyroid may represent all the thyroid gland and since its surgical removal is difficult because of its relative inaccessibility, an operation should not be undertaken unless the tumor produces definite symptoms. However, should symptoms develop to require treatment, partial or complete excision of the tumor is indicated. The approach is through the mouth and to insure a free passageway for air during the course of the operation preliminary tracheal intubation has been recommended.

**Thyroglossal Duct Cyst or Fistula.**—[See section on *Thyroglossal Cysts and Fistulas*]

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## THE PARATHYROID GLANDS

### ANATOMY AND PHYSIOLOGY

**Anatomy**—The parathyroid glands first appear as definite structures in the amphibia and are present and so far as is known exert an analogous function in reptiles birds and mammals They are developed from dorsocranial thickenings of the epithelium of the third and fourth branchial pouches in the embryo in mammals and accordingly are often intimately associated anatomically with the thymus which arises from ventral outgrowths of these same structures In their further development the parathyroids become separated from the primitive gullet and in many animals are more or less completely enclosed within the lateral lobes of the thyroid which develop from the epithelium of the fifth branchial pouch Commonly there are four glands two closely associated with each thyroid lobe and a varying number of islands or nodules of accessory parathyroid in the thymus or in the connective tissue in the anterior mediastinum along the trachea, arch of the aorta or pulmonary artery In mammals the four glands weigh less than half a gram They are made up of strands of epithelial cells supported by a reticulum of endothelial cells of varying size and shape and enclosed by a connective tissue capsule Often there is no definite columnar arrangement the cells appearing in masses or clumps but sometimes there is follicle formation containing colloid the significance of which is unknown The parenchyma consists of fairly large polygonal cells with deeply staining nuclei and poorly staining cytoplasm the chief cells and a smaller number of slightly smaller cells with granular deeply staining cytoplasm and small central nuclei the chromophile cells The blood supply to the parathyroids is by way of the superior and inferior thyroid arteries and is very abundant Nerves to the parathyroids accompanying the blood vessels have been described some of which terminate in the vessel walls but many of which penetrate between the epithelial cells forming nodular enlargements The function of these nerves is unknown Transplant experiments have demonstrated however that the parathyroids can function adequately in the absence of all nervous connections.

**Physiology**.—The parathyroids belong to the group of endocrine glands and perform their vital function by means of an internal secretion An extract of the glands containing the specific hormone in fairly pure form was prepared by Hanson (1923) and Collip (1925) and is available in the market for clinical use It is biologically standardized and is effective only on subcutaneous or slow intravenous injection When the parathyroid glands are removed or destroyed by disease a syndrome known as parathyroid tetany develops in a few days and rapidly leads to death unless adequate therapy is instituted The careful injection of potent parathyroid extracts will control these deficiency symptoms

An intimate relation has been established between the function of the parathyroid glands and the metabolism of calcium and phosphorus When the glands are removed or suddenly destroyed by disease the concentration of total calcium in the blood serum decreases the ionized calcium decreases, the inorganic phosphorus rises and the excretion of phosphorus in the urine is lessened The administration of parathyroid extract corrects these alterations while excessive doses raise the serum calcium to very high levels, bring about the removal of calcium and phosphorus from the bones and accelerate the excretion of these substances in the urine and feces Presumably under normal conditions the amount of parathyroid hormone liberated from the glands suffices to keep the level of serum calcium constant in spite of variables in the way of absorption from the alimentary tract and excretion or withdrawal in special cases such as pregnancy or lactation In common with several of the other endocrine organs disturbances due to hypofunction and hyperfunction of the parathyroids are clearly recognized

### HYPOFUNCTION OF THE PARATHYROID GLANDS

Deficiency symptoms are seen most commonly in animals following experimental extirpation and in man as a result of accidental injury to the parathyroid glands in goiter operations When all of the glands are removed or destroyed in man or the lower animals severe tetany ensues within

two or three days characterized by fibrillary tremors of the voluntary muscles intermittent attacks of tonic and clonic convulsions hyperpnea salivation severe depression and death Fortunately in man such an abrupt loss of all parathyroid tissue rarely occurs the functional deficiency is only partial and milder symptoms develop in some cases to be made manifest only under special conditions The cardinal symptom is increased irritability of the peripheral motor nerves so that they are more easily excited by electrical stimulation (Erb's sign) mechanical stimulation (Chvostek's sign) or respiration (Trousseau's sign) than are normal nerves Most patients never experience convulsions but complain of stiffness in various muscles especially those of the fingers legs face and neck and cramps in the extremities Spastic contractions in the fingers and toes may be seen which are aggravated by temporary circulatory occlusion

The most reliable sign of hypofunction of the parathyroid glands is the decreased concentration of the serum calcium from a normal of between 10 and 12 mg to between 8 and 6 mg or even lower and the elevation in the serum phosphorus It is probable that the hyperirritability of the motor nerves in this condition is due to the abrupt alteration in the concentration of the various ions in the blood and lymph and of these the decrease in calcium ions seems to be the most important One manifestation of the disturbed calcium metabolism is the lessened deposition of calcium in osteoid tissue so that fractures heal with difficulty and non union is frequent The frequent occurrence of bilateral cataracts is one of the tragic consequences of parathyroid insufficiency and emphasizes the danger of indiscriminate surgical removal

The treatment of hypoparathyroidism is fortunately fairly adequate Acute cases may be controlled by subcutaneous injection of parathyroid extract (Collip) or intravenous injection of 5 per cent  $\text{CaCl}_2$  solution or Ringer's solution (1500 cc) For continued treatment which is usually necessary it is best to place the patient on a meat free diet and give from 5 to 25 Gm of calcium lactate or gluconate and from 25 to 50 Gm of lactose drub by mouth Dihydroxyacetone a synthetic product pro-

duced by irradiating ergosterol causes a long-continued rise in the blood calcium level when given by mouth and is a most useful drug for the treatment of chronic hypoparathyroidism It is available as a 0.5 per cent solution in oil and is given in doses of 1 to 3 cc daily Frequent estimations of the blood calcium content should be made with adjustment of the dosage

#### HYPERFUNCTION OF THE PARATHYROID GLANDS

Systemic symptoms due to the liberation into the blood of an abnormally large amount of the parathyroid hormone are seen most commonly when a parathyroid adenoma is present but may occasionally occur in generalized hyperplasia of all parathyroid tissue The adenoma may occur in any of the normal sites of the four glands but has also been found to involve accessory parathyroid tissue in the mediastinum and elsewhere The tumor is grossly an encapsulated soft lobulated yellowish gray mass which is composed of syncytium like groups of large cells containing large oval darkly stained nuclei with abundant pale granular cytoplasm and closely packed or arranged in small alveoli enclosing colloid The adenoma is usually too small to produce local symptoms but the general manifestations may be profound The disease is more common in females and is most frequent in the middle decade of life The onset is insidious and the course of the disease may extend over many years The symptoms are all referable to the influence of the excessive amounts of the hormone in removing calcium and phosphorus from the skeleton and causing their excretion in the urine Pain in the bones intensified by exercise and general bone tenderness are commonly seen X-ray examination of the skeleton reveals the characteristic changes of osteitis fibrosa cystica or von Recklinghausen's disease and this disease is now known to be due to hyperparathyroidism The principal changes are generalized decalcification of the skeleton with thinning of the cortex and trabeculae of the long bones the formation of multiple bone cysts and giant cell tumors or osteoclastomas and in late stages spontaneous fractures and deformities due to generalized softening of the



bones Polydipsia polyuria muscular weakness constipation loss of appetite and leukopenia are frequent symptoms. In about 30 per cent of the cases the excessive excretion of calcium and phosphate in the urine leads to the formation of calculi in the kidney pelvis and symptoms of renal colic or to the deposition of calcium phosphate in the kidney parenchyma with secondary contracture and renal insufficiency. This nephrocalcinosis has frequently led to the diagnosis of the disease. This is most dependably made by laboratory examinations which reveal hypercalcemia hypophosphatemia hypercalciuria hyperphosphaturia and a negative calcium balance.

**Treatment of hyperparathyroidism** consists in the discovery and removal of the responsible parathyroid adenoma. The surgeon must secure a bloodless field and be prepared to examine the usual sites of the glands and if necessary to enter the mediastinum. The removal of the adenoma may cause such an abrupt fall in the serum calcium content as to precipitate severe or fatal tetany. This should be guarded against by the adoption of the methods previously described for the treatment of hypoparathyroidism. Operations have been performed in about 125 cases of osteitis fibrosa cystica in which the laboratory and clinical findings of hyperparathyroidism were present. In about 80 per cent of these a parathyroid adenoma has been found and removed. The results have been for the most part strikingly beneficial. The blood calcium content has rapidly declined to its normal level and the increased excretion of calcium and phosphorus in the urine has ceased. The patients have gained in weight and strength and joint and bone pains and tenderness have disappeared. X-ray examination of the skeleton has revealed a progressive increase in density and the cystic spaces have become largely replaced by normal bone. In those cases in which a parathyroid adenoma was not found at operation and one or two of the normal glands were removed persistence or recurrence of symptoms has been the rule. In these it is probable that an adenoma was present probably associated with aberrant parathyroid tissue in the mediastinum in the substance of the thyroid or elsewhere where its discovery presented great technical difficulties.

In a few instances generalized hyperplasia of all parathyroid tissue has been reported at operation and in these the extirpation of one or two of the enlarged glands has resulted in temporary improvement. The results however have not been as definite as those that follow the removal of the adenoma.

At present there is no good evidence that Paget's disease ankylosing polyarthritis osteomalacia or osteogenesis imperfecta is due to hyperparathyroidism and parathyroidectomy is not indicated in these diseases.

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## ABNORMALITIES OF THE THYMUS

Many interesting studies have been performed in an attempt to determine the function of the thymus. The early observations of a number of investigators indicated that the thymus is concerned with calcium metabolism and with the growth of bone. Subsequent studies by Park and McClure showed that the previous findings were due to inadequate diet and confinement of the animals rather than to thymectomy. The evidence concerning the relationship of the thymus and the gonads is controversial and will not be discussed here. Linn and Rowntree found that thymectomy results in a retardation of growth in successive generations of rats commencing in the second generation. The interesting observation was made by Gudernatsch that the feeding of thymus tissue to tadpoles was followed by an increase in the rate of growth and by retarded metamorphosis. Asher and Row-

tree found that multiple injections of thymic extracts influence the rate of growth of rats. The most amazing observations are those of Adler who states that the multiple injection of thymic extract or the implantation of thymic tissue into dogs causes a syndrome resembling myasthenia gravis in the human.

Despite the large number of clinical and experimental observations the function of the thymus is unknown. From the clinical viewpoint the most suggestive evidence that the thymus has a function arises from the frequent association of benign tumors of the thymus and myasthenia gravis and from the relationship of enlargement of the thymus and thyrotoxicosis.

### HYPERPLASIA

Normally the thymus increases in size up to the age of two or three years and usually remains at approximately this size until the twelfth year. Following this it decreases slowly in size and may disappear entirely.

Hyperplasia of the thymus may occur particularly in children and may result in respiratory difficulty. This does not occur as frequently as was previously believed to be the case. Thymectomy has been employed successfully for the relief of dyspnea but the operation has been replaced by radiation therapy with equally good results.

Little is known about status thymicolymphaticus in which there is an enlarged thymus and hypertrophy of all the lymphatic tissues. In fact many deny the existence of such a clinical entity. At any rate it seems likely that too many otherwise unexplainable anesthetic deaths have been ascribed to status thymicolymphaticus. In this connection it should be remembered that prolonged illnesses are accompanied by a decrease in the size of the thymus and that the thymus of a previously well child who dies suddenly is normally rather large.

### MALIGNANT TUMORS

The majority of thymic tumors are malignant. It is difficult to establish the thymic origin of a tumor unless Hassall's corpuscles are found on microscopic examination. Living has given an excellent description of the variations in structure which may be encountered in thymic tumors. He states

that a full survey of the structural variations reveal at one extreme a mixed process involving lymphocytes and reticular cells with giant plasma and eosinophil cells producing a structure nearly identical with Hodgkin's granuloma and at the other extreme nearly pure tumors of rounded or polyhedral reticular cells namely lymphosarcoma and carcinoma. More than 200 malignant tumors of the thymus have been reported in the literature.

The clinical picture presented by patients with malignant thymic tumors resembles that of patients with other malignant tumors of the anterior mediastinum. The symptoms in the main are those of progressive mediastinal compression. Pleural effusion, tachycardia and anemia may be present.

The diagnosis is usually not made until the mass reaches a rather large size. The symptoms of compression the physical signs of an anterior mediastinal mass and the x-ray shadow should suggest the diagnosis.

Treatment is unsatisfactory and patients rarely live more than a few months after the lesion is discovered. Roentgenotherapy is preferable to an attempt at extirpation by surgical means.

### BENIGN TUMORS

Benign tumors of the thymus are rare and most of those that have been reported were in patients with myasthenia gravis. Bell stated that the thymic tumors occurring in such patients form a distinct group. He collected from the literature of 1901-1917 reports of 56 cases of myasthenia gravis in which autopsies or operations had been performed and in 27 of these cases abnormalities of the thymus were exhibited. The corresponding figures in 1939 were 52 abnormalities of the thymus in 110 operations or autopsies upon patients with myasthenia gravis (Blalock, Mason, Morgan and Riven). The frequent association of benign tumors or hyperplasia and myasthenia would appear to be more than a coincidence.

If a benign tumor reaches a large size which is usually not the case the symptoms are those of progressive mediastinal compression.

The diagnosis of a benign tumor is usually made as a result of suspecting such a

lesion in association with myasthenia gravis. The tumor is usually demonstrated best on a lateral roentgenogram.

Remissions in myasthenia gravis are not uncommon and it is difficult to judge the effects of therapy. Surgical extirpation of a benign thymic tumor has been followed by marked improvement in most cases in which this form of therapy has been used.

The effects of total thymectomy in the absence of a thymic tumor are less definite. This form of therapy was suggested by Blalock, Harvey, Ford and Ilienthal in 1941. There has been sufficient improvement (Blalock, Carson and Keynes) in most of the patients to warrant this operation on those with severe myasthenia gravis.

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## THE ISLANDS OF LANGERHANS

### HYPOGLYCEMIA

After Minkowski established the fact that total extirpation of the pancreas in the experimental animal is associated with glycosuria, evidence began to accumulate pointing to the presence of an internal secretion produced by this organ and having to do with carbohydrate metabolism. Later Opie showed that the elaboration of this secretion comes from the islands of Langerhans. Bensley demonstrated that the beta cells of the islands have the particular function of secreting a substance concerned with carbohydrate breakdown. This sub-

stance was subsequently isolated by Banting and Best and given the name of insulin. Insulin lowers the level of sugar in the blood.

**Symptomatology.**—With the appearance of widespread clinical use of insulin, reports of symptoms of overdosage began to appear. The most remarkable effect of such an overdose is a very noticeable lowering of the amount of sugar in the blood. The acute hypoglycemia in turn is associated with phenomena such as malaise, lassitude, inability to perform mental or physical work, trembling and sweating, alternate pallor and flushing of the face, a sensation of hunger which sometimes may be extreme, mental confusion resembling alcohol intoxication, epileptoid convulsions, coma, and even death. In 1924 Seale Harris<sup>1</sup> demonstrated the presence of hypoglycemia appearing spontaneously and associated with the identical symptomatology as that described when too much insulin is injected into the blood stream. He accordingly suggested that a condition of hyperinsulinism or dysinsulinism can occur spontaneously.

The first positive evidence that such a condition can be associated with an organic lesion of the pancreas was presented by Wilder, Allan, Power and Robertson<sup>2</sup> in 1927. Their report concerned a man who had many of the symptoms mentioned together with a low blood sugar level. At operation there was found an inoperable carcinoma of the island tissue with metastases to the liver. Their demonstration of the presence of insulin in the metastases from the tumor was a most important contribution. Shortly after the publication of this observation, other examples of tumors of the island tissue differing somewhat in type began to appear. Very rapidly a considerable amount of clinical and experimental data related to this subject was amassed. So extensive is this literature that a careful detailed review would require a monograph of considerable size. The surgical removal of the tumor of the island tissue with dramatic relief of symptoms has been reported well over a hundred times in the literature, and these reports probably represent only a small number of the operations that have been done.<sup>3</sup>

**Pathology.**—For the most part the tumors which have been removed have been

small measuring not more than 1 or 2 cm in diameter although in one case a tumor which weighed 500 Gm was successfully removed. At operation the tumor usually appears as a small slightly evanescent elevation from the surface of the pancreas. It is also somewhat firmer than the substance of the gland and may be present in any part of the organ. In some cases it has been well encapsulated while in others it has been necessary to excise normal pancreatic tissue around the tumor in order to remove it completely. Microscopically these tumors have been composed of cells showing a marked tendency to resemble the beta type of cell and the symptoms of hypoglycemia are generally in direct proportion in their severity to the extent of this differentiation into the insulin producing cells. Hyalinization and degeneration also are occasionally seen and appear to be related to the delicate but extensive blood vessels which these tumors possess.

Microscopically encapsulation for the most part is absent or incomplete. There is a definite tendency for the tumor cells to penetrate through the adventitious fibrous capsular tissue and this has led to considerable difference of opinion as to what constitutes adenoma and what is carcinoma. Those tumors that have not invaded blood vessels and have not extended outside of the pancreas have generally responded as benign lesions and for practical purposes such evidences of extension may be used as a point of differentiation between adenoma and carcinoma. In carcinoma as in adenoma the severity of the hypoglycemic symptoms seems to be related more to the amount of differentiation toward the beta cells present in the cancer than to the size or the extent of the lesion. When these tumors metastasize the most common site is the liver. Invasion into the regional lymph nodes and into the contiguous tissues about the pancreas has occurred but is extremely rare. Multiple benign tumors may occur and the entire pancreas should be examined for such a situation. The genesis of the island cell tumor is probably from the duct cell. The epithelium of the duct is multipotent capable of forming either acinar or island tissue while a mature beta cell probably possesses a poor capacity for regeneration. Furthermore

there is a great tendency to the resemblance of duct epithelium in many of the cells of the tumors. Ducts have been shown to be present in some of these lesions. It is questionable if true acinar cells are ever found in these island tumors just as island tissue is difficult to demonstrate in acinar cancers.

Occasionally a patient presenting symptoms of hypoglycemia has been operated upon and no tumor found. Many of these patients have been thought to have had a diffuse hyperplasia of the island tissue. Because of the normal variation in size and number of islands such statements must be received with caution. An island may normally vary in size from a single cell to a mass as large as 300 or more microns in diameter. Because of such unusual variations therefore any conception of the production of hypoglycemia as a result of increase in the amount of normal island tissue is most difficult to prove. For a more extensive discussion of the pathology of tumors of the island cells reference may be made to the papers on this subject by O'Leary and Womack,<sup>4</sup> Duff and Gomori.<sup>6</sup>

**Diagnosis**—The diagnosis of tumor of the island tissue of the pancreas may at times be extremely difficult to make with certainty. Usually however this is not so. Whenever one is confronted with a patient whose fasting blood sugar level is persistently low (50 mg per cent or less) the presence of an adenoma should be strongly suspected. This suspicion will be stronger if the patient also has a history of mental confusion or epileptiform convulsions before breakfast which are relieved by the ingestion of sweet food or drinks. But similar symptoms have been found associated with pituitary tumors and occasionally even with adrenal tumors. Again it is essential that a distinction be made between a chronic and an acute condition of hypoglycemia. After excessive overindulgence in carbohydrate food the withdrawal of carbohydrates will sometimes lead to the production of acute hypoglycemia and its train of characteristic symptoms which may continue for more than twenty-four hours. This condition is particularly prevalent among children and has been noted frequently at the St. Louis Children's Hospital. The most probable explanation is that the excessive ingestion of

carbohydrate food calls forth an excessive production of insulin which is maintained for several hours after the excessive supply of sugar has been stopped. The condition is therefore analogous to insulin shock produced by artificial injection of an overdose of insulin. Obviously there is no indication for surgical exploration of the pancreas in such cases.

In the establishment of the diagnosis of a tumor the patient must present certain symptoms usually found associated with hypoglycemia and during the time these symptoms are present the patient must be shown to have hypoglycemia. Following the administration of glucose these symptoms must disappear immediately. If the symptoms ever appear with a relatively normal blood sugar level or if the low blood sugar level is inconstant they probably are not due to hypoglycemia and under such circumstances removal of a portion of the pancreas is of little value. If characteristic hypoglycemic symptoms can ever be shown to exist with a normal blood sugar level the resection of a portion of the pancreas so that there will be a constant normal blood sugar will probably not relieve the symptoms.

**Treatment**—When a tumor can be demonstrated to be present the most satisfactory treatment is extirpation. Adequate exposure of the pancreas may be obtained through either the gastrohepatic omentum or the gastrosplenic omentum depending upon the habitus of the patient. In searching for a tumor it is advisable not only to explore the entire anterior surface of the pancreas but also to mobilize the body and tail sufficiently from below to permit some rotation of it forward. This procedure will usually permit a partial examination of the posterior surface of the gland. The head of the pancreas may be examined by incising the lateral peritoneal reflection of the duodenum in such a way that it may be mobilized. On very rare occasions one will encounter a constant persistent hypoglycemia not associated with pancreatic tumor. In a case reported by Graham and Hartmann<sup>7</sup> no tumor was found at operation on an infant one year of age who had well marked symptoms and who had shown blood sugar level indicative of hypoglycemia since the age of

three months. Accordingly in spite of the fact that the pancreas appeared normal subtotal resection of it was performed leaving only a small remnant of pancreatic tissue in the curve of the duodenum to protect the common bile duct. It was estimated that between 80 and 90 per cent of the pancreas was removed. Immediately after the operation the blood sugar value returned to normal and all of the symptoms of hypoglycemia disappeared. Previously the child's mentality had been markedly retarded probably because of the chronic hypoglycemia and this showed some definite improvement after operation. After ten years there has been no return of the hypoglycemic symptoms. This case is cited to call attention to the fact that if an attempt is made to remove pancreatic tissue where no tumor is present at least 80 or 90 per cent of the pancreas must be extirpated. However in most instances in which tumor is not present there is no primary overabundance of islet tissue and the disorder can be taken care of by dietary measures even better than surgically. The use of certain chemicals that seem to possess the specific ability to destroy beta cells may be considered in certain instances. One must always bear in mind the frequency of moderate hypoglycemia in certain anxiety states.

It is probably a wise precaution to institute drainage in all cases after the removal of an adenoma or of any portion of the pancreas because in the majority of instances there will be an escape of pancreatic secretion for a variable period. In our experience such pancreatic drainage has never lasted longer than six weeks and is not associated with digestion of the surrounding tissues or of the skin that comes in contact with the secretions.

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## THE ADRENAL GLANDS

There are two adrenal or suprarenal glands found as the name implies in close association with the upper pole of the kidneys. Each gland consists of two parts, cortex and medulla which from the standpoint of their embryology and function are separate and distinct organs of internal secretion. The cortex is made up of columns of cells containing glistening granules of lipid material. It belongs to the so-called internal renal system and develops from the ventral part of the mesoderm which also gives rise to the sex glands. The medulla contains numerous nerve and ganglion cells and the characteristic large polygonal cells the chromaffin cells which take a brown color when stained with chromic acid. The medulla develops from that part of the ectoderm from which arises the sympathetic nervous system. Because of the intimate anatomical relationship between the adrenal cortex and medulla in man it is probable that both structures are often involved in the same disease process and a highly complex clinical disturbance is produced. While a great deal has been added to our knowledge of the function of these glands in the last few years much remains to be discovered. Aside from the treatment of primary tumors by extirpation or radiation surgery of the adrenal glands is at present in a frankly experimental stage and should be undertaken only by those who understand what they are about are conversant with the experimental literature in the field and are willing and able to make accurate observations of the effects produced.

### THE ADRENAL CORTEX

Complete extirpation of both adrenal glands in most species results in death in a

few days following symptoms of anorexia, vascular collapse and depression. The cortex is the portion of the gland necessary for life since dogs have been maintained in good condition for long periods of time after removal of all trace of medullary tissue. It is now clear that this vital function of the cortex is performed by means of a specific internal secretion, active extracts of which have been obtained by Swingle and Pfaffner and Hartman. Careful subcutaneous or intravenous administration of this extract will preserve the life of an adrenalectomized animal indefinitely and correct all deficiency symptoms. The exact role played by the adrenal cortex or its hormone and the precise nature of the disturbance resulting from the loss of cortical function have not yet been determined. In some not well defined way it is concerned with circulatory efficiency, blood volume and the partition of water in the tissues, appetite and nutrition.

**Hypofunction of the Adrenal Cortex**—Sudden destruction of the adrenals occurs occasionally as a result of hemorrhage and is usually fatal in a few days. A gradual destruction of the glands produces the symptom complex known as *Addison's disease*. It is likely that this is a composite due to the loss of function of both cortex and medulla, the cortex playing the more important role. In from 80 to 90 per cent of cases the destruction of the gland is due to tubercle, the remainder being due to atrophy of an undetermined origin. The onset is usually insidious and the most prominent symptoms in the order of their occurrence are as follows: (1) fatigue, muscular weakness and general languor, (2) bronze pigmentation of the skin and mucous membranes, (3) anorexia, nausea and vomiting, (4) loss of weight, (5) arterial hypotension, (6) severe anemia and (7) circulatory collapse. The disease is progressive and although remissions occur surprisingly like the case of pernicious anemia, most patients eventually die. Treatment is symptomatic with the daily administration by subcutaneous or intravenous injection of an adequate amount of the aqueous extract containing the cortical hormone. The extract will control the clinical manifestations of Addison's disease in the majority of cases and its recent discovery has given new hope for this hitherto

incurable disease. The time is still too short to pass final judgment. At present however, the prognosis is extremely grave owing in part to the associated tuberculosis and to the difficulty and expense in securing adequate amounts of the potent extract.

### Hyperfunction of the Adrenal Cortex

—Systemic symptoms due to long continued administration of excessive amounts of the cortical hormone have not yet been clearly defined. Our knowledge here is limited to the observations that have been recorded in cases of primary tumors of the adrenal cortex in which it is inferred that the tumor produces an excessive amount of hormone in a manner analogous to the situation in parathyroid adenoma and islet tumor of the pancreas. Primary tumors of the adrenals are unusually rare. Burke (1934) reports that of 46,000 hospital admissions a primary adrenal tumor was found in only 4 cases. Two of these were in the cortex and 2 in the medulla. These cortical tumors presumably through their elaboration of excessive amounts of the cortical hormone exert a profound effect on the development and function of the gonads. In the fetus such tumors have been found associated with pseudohermaphroditism in the infant with excessive growth and early maturation of the external sex organs and secondary sex characters and in the adult female with virilism and hirsutism of the male type. Amenorrhea, hyperglycemia, obesity, acne, form eruptions of the skin and hypertension are more or less characteristic symptoms. A somewhat similar clinical picture has been observed in patients with basophilic adenomas of the anterior pituitary body and with certain types of ovarian tumors. Exploration of the adrenals is justified when other cause for the disease cannot be found or if there is local evidence of cortical tumor. In several instances the removal of a cortical adenoma or carcinoma has been followed by recovery or marked temporary improvement.

### THE ADRENAL MEDULLA

In 1895 Oliver and Schafer discovered that intravenous injection of watery extracts of the adrenal glands would cause elevation of the blood pressure. Five years later Abel and Takamine isolated and synthesized adrenalin and in 1904 Elliott demonstrated

that the biologic effect of adrenalin was similar to that obtained by stimulating the sympathetic nerves. In 1905 Driver discovered that the stimulation of sympathetic fibers going to the adrenal glands would result in the liberation of increased amounts of adrenalin into the blood stream and raise the systemic blood pressure. By careful extraction experiments it has been demonstrated that most if not all of the adrenalin comes from the medulla and little or none from the cortex. On the basis of biologic tests it was believed by some of the early workers in this field that adrenalin exists in a constant but minute concentration in the circulating blood being supplied by a continuous secretion of the medulla. The assumption was made that this amount of adrenalin produces a continuous slight stimulation of the sympathetic system and thus through the vasomotor nerves maintains the blood pressure. The vascular collapse in Addison's disease and after adrenalectomy seemed to support this view. The demonstration however by Stewart and Rogoff and by Cannon that dogs can survive in good condition and with a normal blood pressure after removal of all trace of medullary tissue or after the removal of one adrenal and denervation of the other so that no adrenalin enters the blood stream proves that neither the adrenal medulla nor its product adrenalin is necessary for life or cardiovascular function. Cannon has supplied a convincing array of experimental evidence that whereas a continuous secretion of adrenalin does not occur under the stimulus of strong emotion evoked by conditions of stress there is an increased output from the glands. Since the physiologic effect of adrenalin is to increase the blood pressure, strengthen the heart beat, elevate the blood sugar value, increase the coagulability of the blood and shift the blood from the less insistent viscera to the organs immediately essential to life, Cannon believes that this response is purposeful and better enables the patient to meet the necessities of flight, combat or pursuit. In other words although adrenalin and the adrenal medulla may play little or no role in quiet comfortable existence they are very important in an emergency.

### Hypofunction of the Adrenal Medulla

—It is probable that more or less complete

destruction of the adrenal medulla occurs in most cases of Addison's disease. The experimental evidence summarized above indicates that most of the symptoms of this disease are due to the associated destruction of the cortex and that a localized destruction of the medulla without involvement of the cortex would cause little or no disturbance. Such a patient might be expected to be less able to withstand the stress and strain of an unfavorable environment. It is of course well known that patients with Addison's disease are exceedingly poor surgical risks but in the present state of knowledge it is not possible to state whether this is due to the loss of the emergency function of the medulla or to the general effect of cortical insufficiency.

### Hyperfunction of the Adrenal Medulla

—Systemic symptoms due to excessive excretion of epinephrine into the blood stream have been observed in a number of patients with a benign adenomatous tumor of the adrenal medulla. A tumor of this type is called a *paraganglioma* or *pheochromocytoma* and when it arises from the extramedullary chromaffin tissue a *paraganglioma*. Chromaffin cell tumor is probably the best name since the predominant cell type has the same origin and staining reactions as the chromaffin cells of the adrenal medulla. Patients with such a tumor have been found to display paroxysmal hypertension together with other symptoms such as pallor, profuse sweating, dyspnea, headache, precordial oppression, bradycardia, nausea and vomiting. The cause of the symptoms is a transitory and periodic outburst of epinephrine from the tumor which may sometimes be brought on by massage or the adoption of certain positions. Extirpation of the tumor with complete and permanent relief has been accomplished in a number of instances. The excised tumor has been found to contain large amounts of epinephrine. Removal of adrenal tumors may be accomplished through the usual kidney incision in those cases in which the tumor is large and its location is demonstrated by x-rays. Insufflation of air into the perirenal tissues is an aid in this delimitation. In most cases, however, it is best to make a transverse incision in the upper abdomen and explore both adrenals. The clinical picture of paroxysmal hyperten-

sion with its attendant phenomena is quite different from that of essential hypertension and there is little or no evidence that the latter is due to hyperfunction of the adrenal medulla. The reported association of hyperplasia of the adrenal medulla in these cases lacks confirmation. Prohaska, Harms and I were able to produce slight persistent hypertension in dogs by the continuous intravenous injection of epinephrine but the associated paralysis of the gastrointestinal tract and the disturbance in carbohydrate metabolism caused death within two weeks. The degree of hyperadrenalemia required to produce hypertension is thus sufficient to cause the death of the individual from the other systemic effects of the hormone. The suggestion that such diverse diseases as ulcer of the stomach and duodenum, hyperthyroidism, neurocirculatory asthenia and diabetes mellitus are due to hyperfunction of the adrenal medulla and may be corrected by adrenal denervation seems unlikely and there is little convincing evidence in its support.

In addition to the primary tumor described the adrenals are occasionally the site of metastases of a malignant epithelial tumor of the breast, esophagus, stomach, testicle or penis and of malignant melanoma. Such involvement is chiefly of pathologic interest.

LESTER R. DRASCHETZ

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## XIII THE NERVOUS SYSTEM

### HEAD INJURIES

It is the fractured skull which is exhibited in our museums not the damaged brain. But what has happened to the skull is of far less moment than what has happened to the brain and this has been given less study. (Cushing)

### THE SCALP

The scalp is frequently traumatized. Surgically the galea aponeurotica a firm fibrous membrane joining the occipitofrontalis muscle and covering the calvarium is of primary importance. Overlying the galea and firmly bound to it by fibrous septa are subcutaneous tissue and skin beneath the galea and separated from it by loose areolar tissue lies the pericranium. This membrane is closely adherent to the skull especially along the suture lines. The rich blood supply of the scalp is derived principally from the occipital postauricular temporal and supraorbital arteries which bleed freely when cut. The sensory nerves are the greater and lesser occipital the auricular temporal and supraorbital branches of the trigeminal. They have exceptional regenerative power and numbness of the scalp secondary to their severance ultimately disappears. When the motor branch of the facial nerve supplying the frontalis muscle is cut permanent ipsilateral paralysis of the forehead results a pertinent fact in planning surgical approaches.

Traumatic lesions include abrasions contusions hematomas lacerations and avulsions they predispose to cellulitis subaponeurotic or subperiosteal infections.

**Abrasions** or brush burns caused by friction may contain dirt. As the freshly abraded surface is moist with serum and exudate vaseline gauze dressings give comfort. They are painlessly removed.

**Contusions** usually follow blunt blows on the resisting skull the scalp occasionally being devitalized.

**Hematomas** may form beneath the galea or pericranium. A subaponeurotic hematoma

frequently assumes enormous proportions there being no limiting membrane to prevent its spread. The firm edges surrounding a central softened area may incorrectly suggest a depressed fracture especially if the galea or pericranium is ruptured. A roentgenogram clarifies the diagnosis. If in doubt one should explore rather than overlook a depressed fracture. Blood may spread for considerable distances under the scalp. A suffusion causing swelling and blackening of both eyelids is often associated with fractures in the frontal region. Following fracture or separation of the sagittal suture a hematoma may form in the midvertex from blood which seeps through the torn outer wall of the longitudinal sinus. This sometimes resembles a dunce cap. Hematomas usually absorb spontaneously. Aspiration or open evacuation is necessary only when the scalp becomes so tight as to impair its nutrition. Drainage is indicated in case of infection. Calcification of subperiosteal hematomas has been described.

**Lacerations** may be single or multiple superficial or deep. Occasionally they bleed dangerously. If the aponeurotic or muscular fibers are cut transversely the wound retracts. Before lacerations are repaired the scalp should be liberally shaved devitalized tissue debrided all dirt removed and the condition of the underlying skull investigated to avoid overlooking a depressed fracture. Separate approximation of the galea with interrupted silk stitches strengthens the wound and permits early removal of the superficial sutures. Healing is prompt.

**Avulsions**—Glancing blows may lift large areas of the scalp separation occurring in the subaponeurotic layer (scalping). Typical avulsions do not involve the bone. Conversely the calvarium is almost invariably injured in punctured or penetrating wounds. When avulsions are extensive generous scalp flaps occasionally are required to secure closure. Ordinarily the prevent a vascularity promotes healing but if the pericranium is denuded the blood supply of the outer table

becomes impoverished requiring multiple perforations to the diploetic spaces. Granulation thus promoted may be skin grafted later.

**Scalp infections** when superficial occasion little disturbance. When they are deep beneath the galea suppuration may extend from the supraorbital to the occipital ridges whereas below the pericranium the attachments of this membrane limit the spread of pus. In either event suitable incisions favor relief preventing secondary osteomyelitis.

**Diffuse cellulitis** is of serious import. The infection may invade the pericranium and advancing by emissary and diploetic veins cause intracranial complications. Externally assuming erysipelatous characteristics it sometimes involves the entire scalp descending to the eyelids and face. Magnesium sulfate compresses (105° F.) are recommended. Fluctuating areas require adequate drainage. All scalp wounds should be dusted with sulfanilamide powder before closure.

### THE SKULL

The cranium consists of a dome-like vault rising above an irregular base. The former includes most of the frontal bone, both parietals, the squamous part of the temporals and occipital and the greater wings of the sphenoid. The base presents three fossae separated by laterally placed sphenoidal and petrosal ridges. The anterior fossa supports the frontal lobes of the cerebrum, the middle fossa its temporal lobes, the posterior fossa the cerebellum. The location of a basal fracture is suggested by the following signs: *Anterior cerebral fossa* (a) subconjunctival hemorrhage, (b) epistaxis if the arachnoid, dura and sclerodermic membranes are torn, and (c) anosmia from injury to the olfactory bulbs or filaments of the olfactory nerves as they cross the cribriform plate. *Middle cerebral fossa* (a) bleeding from one or both ears, (b) cerebrospinal otorrhea, (c) peripheral facial paralysis, (d) deafness or tinnitus, and (e) rarely tearing of the lateral sinuses or internal carotid artery. *Posterior or cerebellar fossa* (a) bleeding into the pharynx if the basilar process of the occipital bone is fractured and the pharyngeal mucosa torn, and (b) ecchymosis at the base of the neck and behind the mastoid (Persol).

Developed from membranous bone the calvarium presents inner and outer tables separated by spaces through which course the diploetic veins readily seen in roentgenograms. Not alone from its spherical shape but also from the stratified construction of its walls layers of bone separated by potential space, the calvarium derives a maximum of strength, an important factor in resisting blows. Likewise the sutures modify the effect of external violence. The principal sutures never to be confused with fractures are the sagittal

coronal and lambdoid. At times however sutures are opened by injury, a result tantamount to fracture. Distinctive roentgenographic markings of the diploetic veins already mentioned must not be misinterpreted for fracture. Similarly the middle meningeal arteries often deeply groove the temporal and parietal bones but the direction and branching are characteristic. If one of these vessels is torn by a fracture extracranial hemorrhage may result. Fractures of the vault heal not by callus but by membranous union. Owing to the slight regenerative power of the bone traumatic or operative defects seldom close. To the pericranium and dura some writers ascribe weak osteogenic functions.

Cartilaginous in origin the base of the skull is much thinner than the vault, separation into tables does not obtain and the floor is penetrated by foramina for the passage of nerves and vessels. The thinnest and weakest part of the floor, that of the middle fossa is the favorite site of basal fractures. The dura adhering more closely to the base than to the vault is most frequently torn in basal fractures. A ring of dense bone about the various foramina protects the structures which traverse them.

**Skull Fractures**—Here elaborate classifications have little practical value. Fractures have been grouped according to location and type. They may be *linear* (fissured, bursting, expansile), *depressed* (indented, stellate) or *penetrating*.

*Linear fractures* are most frequent. Their production depends on certain elastic qualities of the skull. If sufficient force is brought against it the skull will be shortened in one diameter, lengthened in another and fracture results from increasing its equatorial circumference. The mechanism resembles that of cracking a nut. Almost invariably the line of fracture follows the direction of the shortest meridian. Naturally linear fractures have various locations and peculiarities because the offending forces differ in intensity and direction and because the cranium is not a perfect sphere. At first the fracture line separates but immediately springs together. If the scalp is simultaneously lacerated and hair or other foreign matter is entrapped in the fracture line the likelihood of infection increases.

Since the base of the skull is its weakest part it is the most common site of fracture. When the line crosses the middle fossa and the dura and eardrum have been ruptured bleeding occurs from one or both ears. Obviously such a fracture is compounded and carries increasing danger of meningitis. Occasionally when the ear does not bleed ex-

ternally inspection discloses a drum bluish and bulging from hemorrhage into the middle ear indisputable evidence of a basal fracture. These can seldom be demonstrated roentgenologically the bleeding ear furnishes the clue. The same significance attaches to blackening of both eyes or cerebrospinal rhinorrhea. Although linear fractures generally avoid the buttresses of the skull they may cross the supraorbital ridges invade the mastoid or enter the foramen magnum. If they communicate with the large basal cisternae the danger of meningitis is increased. Linear fractures heal slowly and demand no treatment.

*Depressed fractures* although less frequent than linear are more important from the standpoint of surgical treatment. Caused by

compression the mosaic pattern can be reconstructed before the fragments are replaced. Fragments are often viable even in the presence of infection. Later should signs of osteomyelitis appear their removal is simple. Indriven fragments which lacerate the dura should be carefully removed. They are a source of cerebral irritation. The dura should be repaired if possible drainage is seldom necessary.

Indentations from obstetrical forceps or pressure of other kinds incidental to birth should be elevated. The question often arises regarding the advisability of elevating small depressed fractures which give no objective neurologic signs. While their elevation may not always be necessary it is better to advise it. Only by correction of the depressed

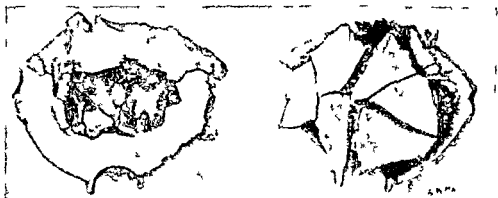


Fig. 118.—A comminuted depressed skull fracture viewed from outer and inner aspects. The inner table is not only more extensively fractured. In correcting such a fracture all fragments should be secured for as far as possible replaced. (Cushig)

direct force like a hammer blow they are often compounded and possess an almost constant peculiarity. If both tables are involved as is usually the case the inner table is more extensively fractured than the outer. This is explained on the principle that the outer table is crowded together by external force while the inner table is spread until its tensile strength is overcome. Therein it resembles a greenstick fracture of a long bone where the part opposite the point of applied force suffers most because it is under the greatest strain (Fig. 118).

When elevating a fracture of this type it is imperative to include the depressed inner table. Much too frequently the outer table is corrected the inner untouched. All fragments should be saved to fill the defect since skull bones have little power of regen-

eration. The mosaic pattern can be reconstructed before the fragments are replaced. The possibility of subsequent convulsions be minimized to the greatest extent.

*Penetrating fractures* invariably compounded result from high velocity projectiles or sharp objects which strike the skull with great force. The torn dura permits bone fragments to be driven into the brain. Penetrating fractures are essentially depressed with the additional features which arise from entrance into the brain of foreign substances, i. e. the missile bone fragments hair or dirt. Post-traumatic convulsions are frequent.

Unless contraindicated by the patient's condition penetrating fractures demand surgical attention. Preliminarily the entire scalp is shaved and the wound carefully cleansed. Occasionally the wound must be enlarged and the fragments removed en bloc with

some surrounding bone. The macerated brain pouts through the torn dura. With a catheter the missile tract is gently irrigated

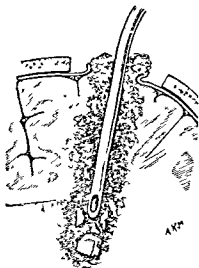


Fig 119—Diagram illustrating the methods of treating penetrating fractures. The tract is irrigated with a catheter, bone fragments and disorganized brain tissue being washed out. The missile often can be seen and easily removed with forceps (Cushing)

with sterile normal salt solution (Fig. 119), and detritus and bone fragments are sucked out. Every bone fragment should be re-



Fig 120—Roentgenogram illustrating several conditions in gunshot wounds of the skull. Indriven metal and bone fragments surround the portal of entry. The bullet has ricocheted from the top of the skull and lodged posteriorly. A typical bursting fracture is produced.

moved, otherwise it may become a nidus for subsequent brain abscess. Particles of metal should be removed when accessible. It is poor judgment to lacerate the brain for this

purpose unnecessarily. "When a bullet has stopped it has done its damage," though axiomatic, is sound teaching. A high velocity missile creates considerable disorganization of the brain substance along its track, caused by the expansile force of the projectile (Fig. 120). Such wounds should be explored early, dusted with sulfanilamide powder and drained or closed tightly.

*Traumatic osteomyelitis* sometimes follows bruising of the scalp though the bone remains intact. More often it results from infection of a compound, depressed fracture. Usually the process affects both tables of the



Fig 121—Osteomyelitis secondary to compound, comminuted depressed fracture of the frontal bone. The rarefying osteomyelitic fragments required removal. A concomitant frontal lobe abscess was drained.

skull, either slowly or rapidly. If slowly, it assumes a sclerosing form and remains localized. The gathering of pus under an infected scalp and outside the dura gives a tender, fluctuant swelling, long known as "Pott's puffy tumor." If spontaneous rupture fails, incision is necessary; subsequently fragments of dead bone are intermittently discharged for many months. Sequestered fragments are easily removed under local anesthesia. With the disappearance of all diseased bone, the wound heals promptly.

The fulminating type of osteomyelitis spreads in the diploetic spaces and traveling to distant parts of the skull establishes fresh

*foci* Thrombosis of the diploetic veins checks its advance. With this type the diseased bone becomes rarefied and porous in contradistinction to the increased density produced by the sclerosing variety. Roentgenographically one can readily differentiate between them. Efficient drainage should be established and sequestration awaited even though fragments are discharged for a long time. To attempt wide excision of osteomyelitic areas is poor judgment. Such attempts are rarely successful as fresh channels are opened through which the infection extends. Epidural or subdural abscesses are familiar complications and cerebral abscesses meningitis and sinus thrombosis not infrequent (Fig 121).

Hematomas of the scalp may become infected the process spreading to the underlying bone, particularly if the pericranium has been ruptured. Occasionally, osteomyelitis of the skull follows diffuse cellulitis of the scalp. It may be blood borne. In syphilitic patients an osteomyelitis most often in the frontal region, may follow a slight scalp bruise. Antiseptic treatment ordinarily suffices.

## THE BRAIN

### Anatomical and Physiologic Considerations—

The brain has two protective coverings the *pachymeninx* or *dura mater* and the *leptomeninx*. The former a tough fibrous relatively non-elastic membrane adheres closely to the inner table of the skull. It assumes the role of an endosteum. Together with the pericranium it furnishes the blood supply to the calvarium the major contribution being made by the dura. This membrane consists of two closely adherent layers which separate at appropriate points to permit the passage of large venous channels and nerve structures.

The intracranial cavity is roughly divided into three chambers by the *falx cerebri* and *tentorium cerebelli*. To furnish passage for the longitudinal sinus the two layers of the *falx* separate. It extends anteroposteriorly from the crista galli to the internal occipital protuberance where it joins the tentorium cerebelli the union of these membranes enclosing the straight sinus. Its lower margin hugs the corpus callosum which separates and protects the cerebral hemispheres. The *tentorium cerebelli* separates the cerebellum from the occipital lobes partitioning the intracranial cavity into the so-called supratentorial and subtentorial chambers. The *falx* and tentorium protect the brain against injury.

The *leptomeninx* includes the pia arachnoid. The pia, a very delicate membrane closely covers the cerebral convolutions. The arachnoid is a loose spider's web-like meshwork in which circulates the cerebrospinal fluid. Between the *pachymeninx* and the *leptomeninx*

exists a potential area called the subdural space. Its importance relates to subdural lesions hemorrhage chronic hematoma and hydroma.

A water bed surrounds the brain. The cerebrospinal fluid is chiefly elaborated by the choroid plexuses situated in the two lateral and the third and fourth ventricles respectively. The fluid formed in the lateral ventricles passes through the foramina of Monro into the third ventricle and with further additions is conducted by the aqueduct of Sylvius to the fourth ventricle. After further slight addition of fluid it passes through the foramen of Magendie and the foramina of Luschka into the subarachnoid spaces. The passage of cerebrospinal fluid from the ventricles through the various subarachnoid spaces is sometimes called "the third circulation." It flows forward along the base of the brain to reach the subarachnoid spaces over the cerebral hemispheres where it is largely absorbed. Its method of absorption like that of formation is not clearly understood. It is chiefly absorbed by the pachymenian granulations which empty through venous radicals into the longitudinal sinus. Other methods of absorption include osmosis through widely distributed capillary walls and arachnoid structures. While passing along the base of the brain the fluid traverses structures resembling lakes or cisternae. Important among these are the cisterna magna the cisterna in terpeduncularis and the cisterna chiasmatica. They afford added protection to the delicate neural structures composing the base of the brain. However they become potential points of danger whenever a compound basal fracture communicates with them for infection so introduced almost invariably leads to meningitis. The water bed thus out beneath the temporal and frontal lobes. This fact combined with the frequency of blows on the occiput or vault suggests why the tips and under surfaces of these lobes more often show bruising than do other parts of the brain. Contusion at a point opposite where a blow is struck is designated "contre-coup" hemorrhage there is called *hemorrhage by contre-coup*.

Following injury blood may enter the cerebrospinal fluid pathways including the ventricles the aqueduct of Sylvius and the subarachnoid spaces. When these rupture fluid collects in the subdural space. It is absorbed mostly in the subarachnoid spaces but occasionally blocks the aqueduct first causing scar formation and later internal hydrocephalus.

**Increased Intracranial Pressure: Physiologic Considerations.**—In considering brain injuries certain physiologic facts become fundamental. The cranium a relatively closed cavity with unyielding walls is filled completely with the brain and various free fluids including arterial and venous blood and the circulating cerebrospinal fluid. One must also include interstitial fluid bound by cell plasma. All these are incompressible. The importance of these fluids becomes evident when after injury, the brain swells. The situation then resembles that produced

by a tight cast enclosing a broken leg. As swelling proceeds, accommodation for the brain is favored by the outflow of cerebrospinal fluid and venous blood. If edema is not marked, sufficient room may thus be provided. Greater swelling, which raises the intracranial above the venous pressure, collapses the cerebral veins. Congestion of the brain follows, for arterial blood still can enter, but the escape of venous blood and cerebrospinal fluid is impaired. Extreme swelling, which raises the intracranial pressure above the arterial, effectively blocks the further outlet of blood. Anemia of the medullary centers follows and death results.

The centers in the brain stem controlling respiration, pulse rate and pulse pressure are readily affected by alterations in intracranial

Cheyne Stokes respiration associated with a sudden rise in pulse rate and a concomitant fall in blood pressure is an ominous sign indicating failure of these vital centers.

The heat regulating center, situated near the floor of the third ventricle, likewise may be affected. When the intracranial pressure is high, there are fluctuations in temperature varying from less than one degree to eight or more degrees. A daily variation of two or more degrees is considered characteristic of cerebral contusion. As intracranial tension drops, the temperature falls intermittently to normal; the regression may take days or weeks (Fig. 122). However, if intracranial pressure becomes excessive, control of the heat regulating center is lost and hyperthermia results. When this occurs, strange

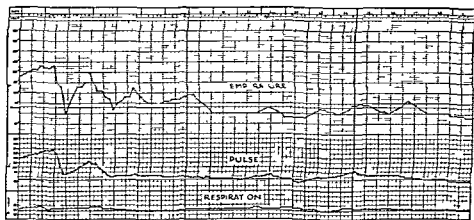


Fig. 122.—Characteristic clinical course in cerebral contusion showing intermittent temperature with corresponding alterations in pulse and respiration rates.

pressure. Whenever the blood pressure alternately rises above and falls below the intracranial tension, characteristic fluctuations occur in breathing (Cheyne Stokes respiration), always a danger sign. Moreover, as the vasomotor center is stimulated, the pulse pressure rises, for the arterial pressure must remain above the intracranial pressure to have life continue. The vasomotor and cardioinhibitory centers function in response to variations between the intracranial and the arterial pressure.

As death approaches, the respiratory center fails first and breathing ceases; then the vasomotor center collapses, causing a sudden drop of blood pressure; finally the cardioinhibitory center gives way with a rising pulse and cardiac failure. Breathing stops several minutes before the heart beat

says the patient seldom sweats. A terminal fever often reaches  $106^{\circ}\text{F}$  or more.

**Gross Pathologic Changes.**—The gravity of a head injury depends on the degree of damage to the brain. While it is important to know whether or not the skull has been fractured, it is far more essential to ascertain how severely the brain has been injured. Trauma most commonly causes cerebral edema. Grossly little is found. That the brain's fluid content is increased is shown at operation by sweating of the arachnoid and at postmortem examination by unusual wetness. Much of the fluid is held in the cytoplasm and perivascular spaces. The choroid plexuses appear reddened and swollen and the amount of circulating cerebrospinal fluid is increased. Pronounced cerebral edema flattens the cerebral convolutions and congests

the vessels Petechial hemorrhages when present indicate more than simple edema

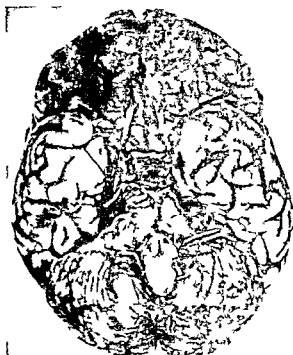


Fig. 123—Basal view of extensive cerebral contusion. The frontal lobes have suffered the brunt of the force but the cerebellum and petal lobes also show damage. The olfactory bulbs have been crushed (frequently a cause of anosmia). Subarachnoid hemorrhage is seen in the sylvian

Contusion of the brain likely to occur anywhere is most frequent along its base

head in rapid motion is suddenly stopped the brain being bruised by impact against the unyielding skull. When the head at rest is struck contusion occurs beneath the point of impact or by contre coup. Contusions often multiple minute or extensive are accompanied by rupture of adjacent vessels (Fig. 123).

Subarachnoid hemorrhage associated with cerebral contusions varies in degree when extensive it covers most of the hemisphere. Its red appearance in life contrasts with the dark currant jelly color at autopsy. Usually the arachnoid membrane is torn permitting seepage into the subdural spaces thus confusing the diagnosis (Fig. 124).

Petechial hemorrhages having grossly a fine spider bite appearance are formed by capillary rupture with extravasation of blood into the perivascular spaces. More numerous in the white than the gray matter they tend to collect toward the base of the brain and in its stem. Ultimately they show patchy gliosis.

Subcortical hemorrhages varying in size are frequently associated with lacerations of the cortex. If near the motor area they predispose to contralateral hemiplegia which appears suddenly in contradistinction to the gradual development following epidural hemorrhages (Fig. 125).

Lacerations of the brain frequently accom-

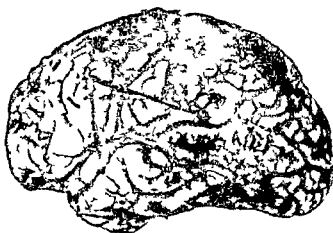


Fig. 124—Widespread subarachnoid hemorrhage a frequent finding which is often associated with secondary bleeding in the subdural space.

The predominant locations are at the tip and under surfaces of the temporal and frontal lobes. Contusion follows when the

parietal depressed or penetrating fractures vary in extent and depth proportionate with the force producing them. In driven bone

fragments or foreign bodies may be deeply embedded. Incrassations produced by through and through gunshot wounds traverse the



Fig 125—Massive subcortical and ventricular hemorrhage shown in tangential section

entire brain. Rarely cerebral laceration occurs without skull fracture.

**Microscopic Pathologic Changes—**Microscopic changes are so numerous that they

into the interstitial tissues, may be present (Fig 126). The ependymal cells become swollen with lakes of fluid within their protoplasm (Fig 126, b). At times fluid expands the perivascular spaces (Virchow-Robin). Whether true pericellular spaces normally exist is not settled, but following injury fluid frequently surrounds the ganglion cells. The oligodendroglia cells show widespread acute swelling (Fig 126, c). Soon after injury the microglia cells show transitional changes and assume the role of phagocytes, engulfing degenerated brain tissue, erythrocytes, myelin, and other debris. Fully developed they are called compound granular corpuscles. Their activity is purely local, that of the oligodendroglia, general. Contusion destroys the ganglion cells with interruption of their fibers, which in the process of degeneration develop peculiar end bulb formations. Gliosis is first shown by changes in the neuroglia cells with abundant increase of astrocytes. Patchy, or widely distributed gliosis occurs only where actual brain damage has taken place. Many of these finer changes in the interstitial tissues are demonstrable only by Cajal's reduced silver staining methods (Fig 127). The microscope also reveals the proliferation of new blood vessels with fibroblastic elements and connective tissue, the collection of red corpuscles in the subarachnoid spaces, especially the



Fig 126—*a* Extensive edema of choroid plexus four hours after injury; hematoxylin and eosin  $\times 190$ . *b* marked swelling and distortion of open lumen with edema of subependymal tissue two days after injury; hematoxylin and eosin  $\times 170$ . *c* widespread acute swelling of oligodendroglia. The ring-like outline of the cells' protoplasm is shown. Penfield's combined method  $\times 700$  (Rand and Courville).

may only be enumerated. In cerebral edema, the living cells of the choroid plexuses swell and vacuolization is increased. Edema and hyperemia of the vessels, even hemorrhage

sulci, fine adhesions between the pia and the cortex, ischemic changes and chromatolysis of the ganglion cells, blood pigment inclusion in ganglion cells, and multiple petechial



hemorrhages. These histologic changes serve to explain certain symptoms mentioned later under postconcussional syndrome.

**Symptoms**—The symptoms resulting from craniocerebral injuries customarily are discussed under the headings *concussion*, *contusion*, and *compression*. With these terms one should be familiar, but it is important to realize that the entities they define merge into each other, being seldom clinically distinct. Reaction of the brain often reaches its peak within two hours after in-

jury, a contestant, knocked out ten rounds to resume fighting. A patient rendered unconscious has no recollection of the blow. The last he remembers is some incident shortly before the injury; the next is awakening with a headache. For an instant following the blow physiologic processes practically stop: the pulse is imperceptible, breathing ceases; there is no response to sensory stimuli; the pupils dilate and the body is limp. However, reaction soon takes place; on recovery of consciousness the patient usually

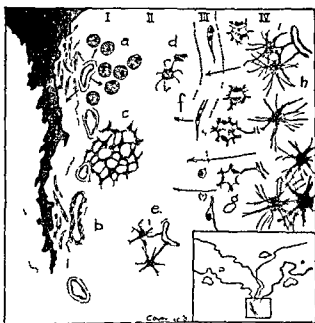


FIG. 197.—Diagrammatic illustration of neuroglial reaction to laceration (late stage). Actively proliferating astrocytes have been plasmoglyosed and lacerated. The arrow indicates the direction of cellular migration. I: Shows the zone of immediate destruction; II: the zone of secondary or delayed laceration; III: the zone of reactive gliosis; IV: the zone of reactive gliosis. a: Corpuscular glial corpuscles arising from the mesodermal elements of the regional blood vessels (in white substance); b: proliferation of fibrillar astrocytes to form a dense mass of glial cells; c: cluster of glial cells; d: dense mass of glial cells; e: patches of densely altered reactive glia; f: bipolar and multipolar forms undergoing reactive reaction; g: fibrillar multipolar astrocytes (glial cells); h: showing regressive changes; a, b, h: hypertrophy and proliferation of fibrillar astrocytes (Cotton).

jury. Hence a complexity of symptoms may develop with amazing rapidity.

**Concussion**—difficult of description generally implies unconsciousness profound or momentary resulting from a blow on the head. Perhaps it is best defined as a series of events resulting from a blow to the head severe enough to cause disruption of intracranial equilibrium (Strauss and Savitsky). Here plainly is the implication of *commotio cerebri*. The brevity of the period of unconsciousness in simple concussion is attested by the rules of the prize ring which

require that a boxer who has been knocked out must remain unconscious for a certain period of time before he is allowed to resume fighting. With the resumption of activity dizziness appears. Vestibular instability may persist for weeks.

What happens during concussion? Momentary interruption of the function of the nerve cell. Beyond this the explanation is theoretical. The suggestions which have been made include jarring of the neurons, separation of the synapses, temporary increase in coagulation of the cell plasma and a sudden increase of electrical discharge. Some hold vasomotor changes responsible. Only rarely does simple concussion cause death and

then gross pathologic lesions are difficult to find

*Contusion and compression* are difficult of clinical differentiation. This is not strange when one reflects that contusion implies edema, bruising and bleeding, any one of which may cause increased intracranial pressure. Unsuspected but sizable lacerations of the brain are often present. The initial clinical symptoms of contusion are essentially those of concussion. However, instead of reviving promptly as with concussion, the patient remains comatose for hours, days or weeks. Periods of restlessness to a point of violence, particularly in alcoholic persons, may intervene. The duration of unconsciousness as recorded clinically and as ultimately estimated by the patient differs widely. Always the patient's estimate is longer. Many automatic acts such as eating, talking or driving a car are not later recalled. The prevailing degree of consciousness is the best single index of the patient's condition. As intracranial pressure increases coma deepens and it lessens the patient's mind becomes clearer.

Contusion causes vomiting, sudden explosive projectile, which is increased by movement of the head. The vomitus often contains swallowed blood.

Daily fluctuation of temperature is characteristic of contusion. The pulse rate varies from moderate slowing in mild contusion to marked slowing in severe pressure. A pulse rate below 60 signifies danger. Concomitant increase in blood pressure accompanies this bradycardia, giving a hard, slow pulse. A sudden increase in the pulse rate associated with falling blood pressure indicates failure of the medullary centers. Respiration ordinarily becomes slow and deep in contusion and labored or Cheyne Stokes in compression.

*Headache* appears as stupor lightens, throbbing at first, it continues with decreasing severity for weeks or months. Since conversion increases the pain, a recumbent position is essential. The patient who remains in bed for the first few weeks materially shortens his convalescence.

*Posture*—A patient with cerebral contusion usually assumes a striking attitude. Characteristically, he lies curled on his side in a position that is almost pathognomonic.

Urinary incontinence often heralds incoming coma. Leukocytosis with from 10,000 to 20,000 cells is a transient phenomenon.

*Cranial Nerve Complications*—The cranial nerves may be temporarily or permanently damaged following head injuries. Frequently single nerves and occasionally groups are affected as they traverse their foramina of exit.

*I Olfactory*—Anosmia is most often associated with fractures which transverse the anterior fossa in the region of the cribriform plate. It results frequently from contusion or laceration of the under surfaces of the frontal lobes in which the olfactory bulbs or nerves participate. Their filaments may be torn in passing through the cribriform plate. Anosmia is almost invariably permanent as nerves of special sense lack the power of regeneration (Fig 193). Usually bilateral and complete, it is sometimes unilateral and incomplete. It is doubly annoying since not only is the sense of smell lost but that of taste is secondarily affected. In certain occupations it constitutes a real disability.

*II Optic*—The eyegrounds should be repeatedly examined. Choked disk appears relatively late, the fundi showing no elevation for the first few days after injury. Conversely, retinal hyperemia occurs early. By watching the increasing engorgement one obtains a fair estimate of the advancing intracranial pressure. Choking is the rule in chronic subdural hematoma and hydroma. It occurs with brain abscess following a penetrating fracture and to a high degree if the aqueduct of Sylvius is blocked by an organized clot. Occasionally choked disk follows craniocerebral injuries unaccompanied by headache, nausea, vomiting or objective neurological signs. Usually it subsides spontaneously and its explanation remains speculative.

If the optic nerves are injured directly, blindness is immediate and permanent. Unilateral blindness due to injury of the corresponding optic nerve near the optic foramen infrequently occurs. Bilateral blindness due to severance of both optic nerves occasionally follows self-inflicted gunshot wounds. Traumatism of the nerve causes primary optic atrophy. The disk of pearly whiteness presents sharp margins, the optic cups and

lamina cribrosa are distinct the arteries are often thread like

Bitemporal hemianopsia secondary to splitting of the optic chiasm in an antero posterior direction, is rare. When present it remains permanent. Concomitant injury of the infundibulum occasionally causes diabetes insipidus (Fig 128)

Hemianopsias directly caused by injury of the optic radiation in gun shot wounds and indirectly in cases of chronic subdural hematomata have been described

**III Oculomotor II Trochlear VI Abducens**—Injury to these nerves causes diplopia. With involvement of all three nerves ophthalmoplegia results. The oculomotor or

The trochlear nerve is rarely involved alone. When it is there is difficulty in looking downward and outward on the affected side, the patient sees double when going downstairs

**I Trigeminal**—If the infraorbital branches of the trigeminal nerve have been torn by fracture of the maxillary bone anesthesia or paresthesia alone, the nose and upper lip develops. The upper teeth are affected when the dental branches are caught. In spite of the tendency of the trigeminal nerve to regenerate complete recovery of an injured infraorbital branch seldom occurs. Consequently subjective discomforts secondary to paresthesia of the face persist. Rarely the

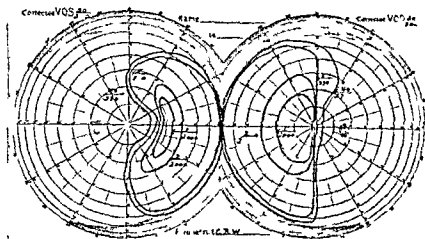


Fig. 128—Bitemporal hemianopsia following injury to the optic chiasm. Temporary blindness plus was an accompaniment of the injury.

the trochlear or both nerves are apt to be associated with injury of the abducens

The *abducens* the longest cranial nerve is frequently affected. The lesion occurs anywhere from the nucleus of its origin to its passage through the sphenoidal fissure. It is often affected in basal fractures associated with hemorrhage. With complete paralysis there is internal strabismus and inability to turn the eyeball outward. Slow recovery is the rule

Complete *oculomotor* paralysis results in external strabismus, ptosis and dilatation of the pupil. The dilatation always of great importance signifies an ipsilateral intracranial lesion. The dilated pupil reacts to light more sluggishly than its mate. Accommodation suffers less. Anisocoria persists indefinitely and may become permanent

gasserian ganglion injured and very rarely is its sensory root torn. My own experience include an instance of anesthesia in the entire trigeminal supply which continued years after injury. Presumably this signified severance of the sensory root, the motor root escaping

**II Facial**—This nerve is rarely torn at its exit from the pons more frequently in its passage through the temporal bone. Most frequently facial paralysis is complete or incomplete is accompanied by bleeding from the ear. Bleeding into the facial canal or edema of the nerve may cause pressure on this structure resulting in a peripheral facial paralysis. Unable to mold the features on the affected side the patient cannot wrinkle his forehead or close his eye. Paralysis of central origin must be distinguished

from the peripheral type. In the central type closure of the eye on the affected side and equal wrinkling of the forehead are unhampered. The paralysis may be permanent. However recovery preceded by fibrillation or twitching may begin shortly strength returning first in the forehead or at the angle of the mouth. One portion of the nerve may recover more completely than another.

Toward securing the desired result massage of the face should be begun early and applied to both the inside and the outside of the cheek. Rotary movements directed upward are most effective. This treatment the patient carries out for himself accurately timed ten minutes three times a day. He should also attempt voluntary movement of the face before a looking glass. The eye should be protected. Electrotherapy has its place. Adhesive straps applied to the face give support.

**VIII Auditory**—This nerve consists of two portions, the cochlear concerned with hearing, the vestibular with equilibration. It is the most frequently affected cranial nerve. It is vulnerable as it passes from the pons to the internal auditory canal and may be torn across or avulsed in this region. The predominant injuries, however, occur as it traverses the temporal bone.

**Cochlear portion** Disturbances of hearing are common especially in basal fractures associated with bleeding from the ear. Diminution of hearing with islands of deafness revealed by the audiometer is the rule. One or both ears may be affected. While ultimate improvement ordinarily occurs complete restoration of hearing seldom takes place. Tinnitus, whether unilateral or bilateral, may be high pitched and faint or low and of greater intensity, a most annoying and persistent symptom sufficient at times to keep a patient bedridden.

**Vestibular portion** Disturbances of equilibration prominent after effects of head injuries become more noticeable with resumption of activity. Apparently they are due to disturbance of both the peripheral and the central vestibular apparatus. One or both nerves may be affected seldom equally. The vertigo or dizziness is accentuated by sudden changes in the position of the head. It is often described as giddiness or light-headedness and is usually of short duration.

Merely looking up brings it on. However it constitutes a disabling symptom in the trades which require climbing. In the majority of cases neuro-otologic studies reveal abnormal vestibular responses. The tests are not least valuable because they serve to identify malingerers.

**IX Glossopharyngeal X Vagus XI Spinal Accessory XII Hypoglossal**—These well protected nerves are seldom damaged. The glossopharyngeal, vagus and spinal accessory may be directly injured by a missile penetrating the jugular foramen. The writer has never seen an injury to the hypoglossal nerve.

**Examination of the Patient**—Since signs and symptoms change rapidly, repeated examinations are imperative. Internal injuries or fractures of long bones may be revealed. A complete neurological survey soon after injury is seldom possible as the patient cannot cooperate. The degree of consciousness should be noted and followed, as it is one of the best indices of the gravity of the case. Whenever possible the cranial nerves should be examined serially. The eye grounds should be examined daily, even though early closing of the disks is not to be expected and special attention paid to the equality of the pupils and their reaction to light. A dilated pupil must be regarded with suspicion; it may be the straw pointing to the side of the lesion. Oculomotor palsies and diplopia should be noted. Inspection of the ear drum seldom necessary, may do harm if the ear is bleeding. Weakness of the face will be recorded as central or peripheral. Disturbances of speech require analysis. In right-handed persons a slowly developing aphasia usually indicates a progressive lesion of the left temporal or frontal lobe. Jargon aphasia should not be confused with irrationality. The visual fields should be examined grossly. Careful observation in a semiconscious patient will often disclose a hemiplegia or hemiparesis. Stimulation of the member will emphasize this. One should watch for signs of convulsions and hemiplegia. The type of convulsions, focal or general, should be carefully noted. Incoordination in the use of an extremity is important. The reflexes must be surveyed carefully and repeatedly for inequality or change. An ankle clonus, positive Babinski, Oppenheim or Gordon sign is sig-

nificant Immediately after severe head injuries all reflexes superficial and deep are lost Their return signifies a favorable reaction their failure to do so is ominous Pulse rate, temperature and respiration should be recorded frequently and the blood pressure carefully followed

**The Spinal Fluid**—Following head injuries the volume of spinal fluid increases Not only is its rate of production augmented but its absorption is disturbed Opinions differ with regard to the advisability of lumbar puncture Some believe that the procedure is dangerous and should never be employed others advocate its routine use A middle course would seem more rational Laboratory study of the spinal fluid yields valuable information The measurement of its pressure furnishes a close estimate of the prevailing intracranial tension A water manometer is preferable (Fig 129) Lumbar puncture should be done with the patient lying on his side a position in which the pressure ranges normally from 100 to 150 mm of water (8 to 12 mm of mercury) In severe injuries it often exceeds 400 mm Its reduction should be carried out slowly, allowing the fluid to escape drop by drop The patient's pulse and respiration must be carefully watched as material change of either means the needle should be withdrawn Daily manometer readings will usually show a gradual drop of spinal fluid pressure Lumbar puncture is condemned if there are signs of medullary disturbance Although respiratory embarrassment and hyperthermia are occasionally relieved by spinal puncture in desperate cases it is likely to do more harm than good The procedure is ill advised whenever the patient is not easily controlled

The amount of free blood in the fluid indicates the degree of intracranial bleeding Obviously the blood removed by puncture is but a small per cent of that actually present Experiments have taught that the subarachnoid spaces absorb blood rapidly Daily examinations show an amazing decrease in the relative amount of blood the fluid first becoming xanthochromic then colorless Repeated punctures and the use of sulfa drugs or of penicillin are recommended in cases of meningitis They seldom save life but they do relieve headache Strictest asepsis is necessary

**Roentgenologic Studies**—*Stereoscopic examination* of the skull is essential A favorable moment should be chosen as satisfactory plates of a restless patient cannot be taken Shock is a contraindication In depressed or penetrating fractures one can visualize the extent of the depression or the location of indriven bone fragments or foreign bodies As linear fractures in themselves require no treatment their identification has

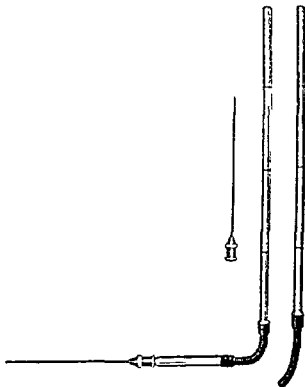


Fig 129—Simple home-made manometer for spinal fluid study A 20-gauge chromium needle is used The manometer consists of an ordinary 1 mm bore glass tube cut to 200 mm length The spring on the bulb represents 50 mm A glass adapter joined to the first manometer by rubber tubing is readily attached to the needle after puncture Should the pressure measure more than 200 mm a second manometer is united to the first The apparatus is easily made and very accurate

little clinical importance unless they communicate with the paranasal sinuses or cross a grooving vessel Many cases showing extensive linear fractures have relatively little cerebral damage and *vice versa* The two conditions must be kept distinct

**Encephalography** never to be employed in acute cases gives valuable information regarding late sequelae The puncture is made preferably with the patient lying on his side Fractional removal of the fluid is

secured by gradually raising the head of the operating table. In order to obtain good roentgenograms from 90 to 140 cc of fluid must be removed and replaced with a slightly smaller amount of air. The difference permits expansion of the air caused by the body's higher temperature thus avoiding the danger of increasing the intracranial pressure. If the pressure is already high encephalography is contraindicated. In a case presenting a postconcussion syndrome encephalography reveals more or less cortical atrophy and enlargement of the ventricles. Occasionally the post traumatic headache is thus relieved.



Fig. 130—Ventriculogram showing both ventricles pushed to the left by a chronic subdural hematoma occupying the right frontal region.

**Ventriculography**—the method of choice in cases of high intracranial pressure gives valuable information in cases of chronic subdural hematomas, latent abscess and hydrocephalus secondary to blocking of the aqueduct or the cisterna magna (Fig. 130).

**Treatment**—*Constant watchfulness is essential.* Routine treatment cannot be outlined as no two cases are alike and unexpected complications often occur. Many patients are badly shocked and for the moment shock is of more concern than the craniocerebral injury. Rapid and careless transportation is condemned. Body heat should be maintained and stimulation administered as needed. Bleeding from external wounds should be staunched. The

administration of fluids in sufficient amounts orally or by hypodermoclysis or even blood transfusion may be necessary. The period of shock sometimes prolonged usually passes within a few hours.

By far the most valuable single measure in the treatment of head injuries is *rest in bed which should continue until all indications of increased intracranial pressure have subsided.* At times this is difficult. Opinionated patients should be told that rest is their best insurance against post-traumatic headache and dizziness. The patient should remain quiet until all headache has disappeared and then is allowed up slowly. If headache returns he should again go to bed. Even after a simple concussion several days of rest is desirable. After more severe injuries from four weeks to several months may be necessary. Rest should be maintained until cerebral vasomotor stability becomes reestablished. It is an impressive fact that patients with head injuries who are forced to rest for long periods because of other fractures simultaneously incurred convalesce most satisfactorily.

Ice to the head with merits long ago recognized proves most effective when several bags are used together. A single bag has little value. Patients welcome cold which benumbs the scalp and lessens pain. The exceptional patient who resists treatment should be humored. Elevating the head of the bed reduces cerebral congestion.

The use of sedatives requires sound judgment. Depressing drugs should be avoided. Morphine employed too generally masks symptoms; it produces sleep indistinguishable from coma; it depresses further an already embarrassed respiratory center and its narcotic effect nullifies the localizing value of a dilated pupil. Occasionally morphine is helpful but it should always be used sparingly. The effect of each small dose should be ascertained before another is given. A nurse's judgment should not be relied on in this regard. Generally codeine is preferable to morphine though the latter may be indicated for shock or pain from internal injuries. Chloral sodium, amytal, sodium luminal and paraldehyde are safer than morphine. Caffeine sodium benzoate an excellent stimulant is said to lower the intracranial pressure and combat shock.

The pulse rate, respiration temperature and blood pressure should be charted at intervals of an hour or less during acute phases. Icebags to combat hyperthermia placed over the carotid, axillary, femoral and popliteal arteries may be removed after the temperature falls below  $102^{\circ} \text{F}$ . For the same purpose, ice water enemas, alcohol and tepid sponges are employed.

Reported turning in bed does not require restraint. A patient often prefers to lie on his side and restraining him on his back only increases the restlessness. Securing the wrists and ankles with loosely tied sheets ordinarily provides adequate restraint, especially when supplemented with well padded side boards. A restraining jacket is seldom necessary.

A bleeding ear should be left alone or at most loosely packed with dry sterile cotton. The bleeding usually stops within a few hours or days. Nature protects a ruptured drum sealing it with a clot and subsequently healing proceeds. A copious flow of cerebrospinal fluid from the ear lowers the intracranial pressure and thus becomes a decompressive agent. The hazard of otitis media or impending meningitis prohibits irrigation. A complicating otitis media should receive conservative treatment. Exceptionally, mastoiditis requires operation. Fatal hemorrhage from the ear is very rare, the writer having seen but one case due to rupture of the jugular bulb.

The degree of increased intracranial tension in cerebral edema and contusion depends largely on the brain's fluid content.

*Dehydration*, much discussed recently as a therapeutic measure following brain injury is secured in three ways: by means of (a) a limitation of the fluid intake, (b) hypertonic solutions and (c) lumbar puncture.

(a) The fluid intake should be limited to from 600 to 1200 cc. or less for the first few days and subsequently restricted for several weeks.

(b) Hypertonic solutions of glucose or sucrose have come into general use. The former a food providing prophylaxis against acidosis has a dehydrating effect which lasts from three to six hours. The latter being a disaccharide cannot be utilized as a food in the blood stream but produces a more last-

ing dehydrating effect frequently for twelve hours. Hypertonic solution of sucrose is a powerful diuretic. No fixed rule can be made relative to the concentration, frequency or amount of hypertonic treatment. Customarily 50 to 100 cc. of a 10 per cent solution of glucose or sucrose is administered intravenously and repeated at intervals of from six to twelve hours. Vigorous dehydration with hypertonic glucose solution causes a short initial rise followed by a secondary fall and a tertiary increase in cerebrospinal fluid pressure. To obtain the desired secondary fall in pressure, one must be prepared for a possible subsequent rise. Thus clinically when injections of hypertonic glucose solution are discontinued and fluid by mouth is substituted, there follows a temporary exacerbation of symptoms. A secondary rise of cerebrospinal fluid pressure does not follow the use of hypertonic sucrose solution. For this reason sucrose has replaced glucose when a dehydrating effect alone is desired. Renal damage especially in elderly persons may result from its overuse.

Magnesium sulfate given orally, an ounce on several successive mornings promotes dehydration. In an unconscious patient a 6 ounce retention enema of a 50 per cent magnesium sulfate solution is helpful. It may be repeated in three hours but is seldom effective after that. The skin should not be allowed to become dry and parched. Dehydration must be carefully watched for it is easily overdone. Unwelcome consequences include secondary bleeding and hypervolemia which may be fatal.

(c) Removal of cerebrospinal fluid by lumbar puncture permits the entrance of more arterial blood and increased oxygenation of the brain. Removal of interstitial fluid favors a greater volume of both blood and cerebrospinal fluid. (For a more detailed discussion see the section on Spinal Fluid.)

*Operative procedures* are confined largely to the evacuation of clots, the removal of indurated fragments or missiles and the correction of depressed fractures. Some patients with cerebral edema who have not responded to various forms of dehydration are benefited by subtemporal decompression with drainage. This is especially true of wet brains.

*The cerebral congestion incident to alcoholic intoxication complicates convalescence from brain injury. Whenever syphilis is suspected of retarding recovery, a Wassermann test makes the situation clear, and appropriate treatment is indicated.*

**Epidural Hemorrhage** (Extradural, interval) —A linear fracture which crosses a meningeal groove in the temporal bone may produce an epidural hemorrhage (Fig. 131). The history is characteristic, and a diagnosis can frequently be made from that alone. The patient usually rendered unconscious by the initial blow recovers consciousness for a time and then again lapses into coma. The period of consciousness, called the "free

plete, Jacksonian convulsions, beginning in the face or arm, are frequent. Bradycardia, increasing blood pressure and Cheyne-Stokes respiration may accompany the second period of unconsciousness. Frequently the pupils are unequal, the larger located on the side of the hemorrhage. Generally the deep reflexes on the hemiplegic side are increased, the Babinski sign is positive and ankle clonus is present. The spinal fluid, usually under increased pressure, theoretically should be clear, but at times oozing into the subdural spaces gives a bloody tinge. An epidural clot forming over a silent area may be overlooked, and fulminating types are known in which death occurs before sur-

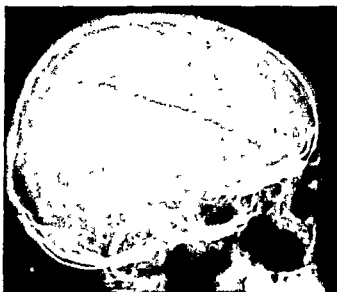


Fig. 131—Linear fracture crossing the meningeal groove, a frequent cause of extradural hemorrhage

interval," varies from minutes to hours, rarely lasting several days. During this interval the patient may have headache and tenderness on the side of the hemorrhage attributable to separation of the dura from the inner table of the skull. Slow but massive bleeding gives signs of contralateral motor weakness. Usually this begins in the face, extends to the upper and finally to the lower extremity and is due to encroachment of the enlarging clot on the motor cortex. Attention is again called to the difference between this type of slowly developing hemiparesis and the rapid hemiplegia resulting from extensive cortical contusion or laceration. In the latter the hemiplegia is not only sudden but usually flaccid and more com-

plete. Jacksonian convulsions, beginning in the face or arm, are frequent. Bradycardia, increasing blood pressure and Cheyne-Stokes respiration may accompany the second period of unconsciousness. Frequently the pupils are unequal, the larger located on the side of the hemorrhage. Generally the deep reflexes on the hemiplegic side are increased, the Babinski sign is positive and ankle clonus is present. The spinal fluid, usually under increased pressure, theoretically should be clear, but at times oozing into the subdural spaces gives a bloody tinge. An epidural clot forming over a silent area may be overlooked, and fulminating types are known in which death occurs before sur-

gical treatment can be instituted. As a rule, however, the clot is disclosed by subtemporal exploration, its removal accomplished and the bleeding controlled (Fig. 132). Subdural hemorrhage results if the meningeal vessels are torn on the under-surface of the dura. More frequently it is secondary to subarachnoid bleeding. Although located predominantly over the parietal or temporal lobes, it may appear elsewhere. Clinically, it closely resembles epidural hemorrhage. The signs and symptoms, however, are usually more fulminating, and the "free interval" may be absent. The clot varies from a mere film to a coagulum several centimeters thick. It is dark, and of currant-jelly consistency. Although the clot is easily washed



from the subdural space operation proves less effective than in the epidural type because of the rapidity of the bleeding.

Subarachnoid hemorrhage presents no characteristic clinical picture and may be small or extensive. When blood seeps into the subdural space stiffness of the neck on flexion develops but there is little restriction on rotation phenomena due to meningeal irritation by free blood. The neck is stiffer whenever the fluid is under increased tension. A bilateral positive Kernig sign is present. These patients usually comatose may show many of the signs and symptoms described under contusion (Fig 124).

as decerebrate rigidity. The entire body is stiff the arms are extended and rotated inward with the wrists flexed and the rigid legs are extended with pronation of the feet. This attitude designated the flapper position resembles the figure of a scud. The clinical course marked by sweating a rapid pulse hyperthermia and Cheyne Stokes breathing often ends fatally (Fig 125).

Chronic subdural hematoma (pachymeningitis haemorrhagica interna traumatica or encapsulated subdural hemorrhage) is a distinct entity. It may appear at any age. Cases have been seen in patients from seven to ninety years of age. The preliminary in



Fig 132—Massive epidural hemorrhage. The dura has been well separated from the inner table of the skull.

Subcortical hemorrhages possible anywhere in the brain substance are frequent at the junction of the gray and white matter. In size they vary from a few millimeters to 5 cm or more. In the region of the motor area or internal capsule they cause contralateral alternating hemiplegia. Such hemorrhages indicate brain injury always severe and often fatal. Occasionally it is possible to explore and remove large subcortical clots; more often they are not amenable to surgical treatment. Hemorrhages into the midbrain or brain stem are generally referable to fracture of the middle or posterior fossa. They give a characteristic picture known

as the "bump on the head" or a playful blow in a game. Often it follows severe injuries involving fracture of the skull. Hemorrhage progresses slowly, usually weeks or even months pass before major symptoms appear. It is often confused with brain tumor as clinically it suggests a gradually increasing intracranial pressure. The symptoms are irregular in progression variability being one of the chief characteristics. Headache intermittent but growing in both severity and frequency an outstanding complaint may be greater on the side of the lesion. Nausea and vomiting

occur vision is disturbed and the disks are frequently choked Restlessness perversity negativism and untidiness are familiar and conspicuous features Mental aberrations provide the excuse for committing such patients to asylums

Localizing signs are few Occasionally jacksonian convulsions homonymous hemianopsia aphasia or mild degrees of motor weakness occur Increased contralateral deep reflexes and a positive Babinski sign may be found *The percussion note over the calvarium is frequently heightened on the side of the hematoma* If anisocoria exists the larger pupil is on the side of the lesion The spinal fluid under increased pressure is at times xanthochromic with its globulin content augmented In late cases the fluid may return to normal in all respects

The hematoma usually unilateral seldom bilateral may attain an enormous size covering the entire frontal with part of the parietal or temporal lobe It is surrounded by a neomembrane having an opaque outer and translucent inner surface The outer membrane attached to the undersurface of the dura has a reddish brown appearance resembling the surface of the liver It consists of organizing granulation tissue containing large mesothelial like spaces The thin translucent inner membrane covered by mesothelium is freely movable over the arachnoid The hemorrhage is venous coming from pial vessels or longitudinal sinus radicals Bilateral hematomas may follow rupture of these radicals The contents of the sac vary Early cases show uncoagulated blood or black clots floating in dark green fluid As the clots disappear the fluid becomes xanthochromic In long standing cases the fluid content may be clear as water Some small hematomas perhaps absorb spontaneously but the majority terminate fatally unless relieved by operation

**Treatment**—Ventriculography localizes the lesion when clinical methods fail Treatment is accomplished in one of three ways (1) emptying and removal of the sac by an osteoplastic approach (2) evacuation and partial removal of the membranes by subtemporal decompression (3) washing out the contents through multiple trephine openings The membranes need not be removed

**Subdural Hydroma** (meningitis serosa circumscripta traumatic serous meningitis)—After certain injuries the ruptured arachnoid membrane allows the cerebrospinal fluid to escape into the subdural space where it cannot be absorbed This may take an acute or chronic form In the former the fluid is free in the latter it becomes encapsulated by a thin translucent membrane Virchow may have had this in mind in describing hydroma of the dura Its symptomatology is almost identical with that of chronic subdural hematoma A large pocket near the motor strip will cause contralateral hemiparesis or hemiplegia In acute cases exploration reveals a sweating arachnoid with an excess of fluid pocketed between the sulci The fluid spurts when the dura is opened and postoperatively drains for several days In chronic cases one encounters a sac of clear fluid surrounded by a thin membrane The condition occurs less frequently than chronic subdural hematoma Favorable results follow operation

**Traumatic pneumocephalus** (intracranial pneumatocele or serocele) a condition signifying the presence of air in the intracranial cavity occasionally follows a skull fracture which communicates with one of the paranasal or mastoid sinuses This creates a portal of entrance for air which may occupy the ventricles subarachnoid or subdural spaces or even penetrate the brain substance The air may enter immediately but more often its entrance is delayed for days possibly weeks The fracture usually crosses the posterior wall of a frontal sinus or the cribriform plate The subjacent dura being torn and the frontal lobe softened a direct route is provided for the passage of air into the intracranial chamber Coughing sneezing or anything which raises the pressure in the paranasal sinuses above the existing intracranial pressure brings this about Cerebrospinal rhinorrhea is frequently present The air is most often pocketed in the frontal lobe Entrance of the air causes terrific headache Roentgenograms graphically show the air Sometimes the patient shows irritability or disorientation or is subject to delusions Strangely the fistulous passage exhibits now and then a ball valve action freely admitting air but blocking its escape A comparable situation occasionally follows when a

fracture communicates with the mastoid cells. Roentgenograms should be frequently repeated to ascertain whether the air is increasing or absorbing.

Evidences of meningeal irritation such as stiffness of the neck, retraction of the head and a positive Kernig sign at times appear. The cerebrospinal fluid may be under increased pressure, the cell count augmented and the globulin content above normal. Leukocytosis may exist. Occasionally bacillary meningitis due to staphylococci, streptococci or pneumococci may develop.

**Treatment**—In approximately 40 per cent of the cases recovery is spontaneous if the patient is kept absolutely recumbent and quiet. He should be cautioned against coughing, sneezing or straining at stool. He should not feed himself. The absorption of air and closure of the fistulous tract will be indicated by the cessation of headache and of cerebrospinal rhinorrhea. In some cases operation is necessary to free the brain of air and to close the rent in the dura. Gratifying results are usually obtained. Recovery has followed operation even in the presence of bacillary meningitis.

**Pneumatocoele crani** is rare. Here gaseous tumors appear beneath the scalp following skull fractures which communicate with the paranasal sinuses. The favorite location of the air, identified by crepitation of the tissues, is the frontal region; it has also been described over the occiput or vertex. As with traumatic pneumocephalus, coughing or sneezing exaggerates the lesion. An appropriate bandage should be put on; occasionally operation is required to close the sinus tract.

**Arteriovenous Aneurysm**—In approximately 70 per cent of the cases of basilar fracture the body of the sphenoid bone is involved. Under such circumstances an abnormal opening or arteriovenous aneurysm between the wall of the internal carotid and the cavernous sinus is not an altogether unexpected complication. This occasions a reversal of the flow of arterial blood into the cavernous sinus. The backflow dilates the cavernous sinus and its communicating veins, particularly the ophthalmic. The aneurysm is usually unilateral, very rarely bilateral and its development is either rapid or slow. Stabbing, knife-like pain centered

behind the affected eyeball and accentuated by a change of position may be the initial symptom. Pulsating exophthalmos occurs in most cases (Fig. 133). This together with an audible bruit and a history of head injury is pathognomonic of arteriovenous aneurysm. Dilatation of the veins of the upper lid, forehead and temple occurs. The scleral vessels become greatly engorged; the optic disk becomes choked and vision is affected. In one case of nasal hemirrhagia blindness could be produced temporarily by compression of the jugular veins. Temporal hemirrhagia, central scotomata and total blindness have



FIG. 133.—Pulsating exophthalmos secondary to arteriovenous aneurysm complicating a basilar skull fracture. The exophthalmos appeared two months after the injury. Note the dilatation of a superficial vein of the forehead and eyelid. A bruit first was audible.

been described. Limitation of extraocular movements increases with the exophthalmos. Diplopia is frequent. Chemosis and corneal ulceration may occur.

A bruit varying in intensity from a soft murmur to a distressing roar and synchronizing with the pulse is audible to the patient. Perceptible to the naked ear the sound becomes very loud when a stethoscope is placed over the adjacent temple or eyelid. It can be stopped or greatly diminished by compression of the corresponding common carotid artery. A convincing demonstration of this fact is easily secured when a stethoscope is placed over the upper lid, the tem-

poral pulse felt and the carotid artery compressed. The bruit and temporal pulse disappear simultaneously. Compression of the jugular vein alone temporarily increases both the bruit and the exophthalmos.

**Treatment**—An arteriovenous aneurysm rarely heals spontaneously. Patients so affected must be quiet. The accepted treatment, ligation of the common or internal carotid, is not without risk as contralateral hemiplegia may result in middle-aged patients. Digital or mechanical compression of the carotid artery should be tried experimentally to determine what effect ligation is likely to have on the collateral cerebral circulation. Whenever the vessel can be compressed for an hour without causing headache, contralateral weakness or tingling of an extremity, operation is permissible. The safest procedure is primary constriction of the vessel with fascial latex, followed later by complete ligation. Sometimes thrombosed orbital veins must be removed later.

**Sequelae**—*Convulsive states following head injury*. Convulsions are rare immediately after head injuries when present they are usually general though focal attacks are not unknown. The jacksonian type usually indicates irritation of the contralateral motor cortex. Its causes include laceration, bleeding, local edema and the presence of embedded foreign bodies. The etiology of general convulsions is less clear. Some patients with a lowered threshold have convulsions from minimal stimuli which ordinarily would not start an attack. The occurrence of decerebrate rigidity soon after an injury is of serious import as it indicates damage to the midbrain or brain stem.

*Post traumatic epilepsy* describes a state in which convulsions develop after a brain injury. Focal or general the attacks are not infrequently delayed until months or years have passed. Encephalography usually shows areas of cortical atrophy and enlargement of the lateral ventricles. When drawn by scar tissue toward the cortical surface the ventricle is said to be wandering. Dense adhesions deep between the damaged brain tissue and its covering membranes often occur. The cicatrix need not be near the motor area to initiate convulsive attacks. However its proximity to this area to a large extent governs their frequency.

**Treatment** is unsatisfactory. The attacks to a large extent may be controlled by phenobarbital and the proper regulation of the diet, activity and habits of life. Extensive removal of the scar has been advocated on the assumption that large operative cerebral defects subsequently fill with fluid and prevent new cicatricial formation.

**Postconcussional state** a term currently used to describe a late train of symptoms following head injuries presents these principal features: headache, dizziness, weakness, vasomotor instability, irritability, memory and dispositional changes, sleeplessness, fear, worry and transient ocular disturbances. The organic and psychogenic factors involved are difficult to differentiate. As might be expected, compensation insurance has brought the psychogenic factor to the front. When it becomes dominant the condition is described as a post traumatic neurosis, traumatic psychoneurosis, psychasthenia or hysteroneurasthenia. It seldom occurs in children.

The intensity of a neurosis bears little relation to the severity of the original trauma. With trivial head injuries patients develop severe neuroses and vice versa. Very humanly, some persons exaggerate their symptoms in the hope of increasing their financial reward. A neurosis seldom improves if a law suit is pending. After a satisfactory settlement the psychogenic or intentional part of the symptoms usually clears up leaving the organic basis which may or may not disappear. Such patients are exceedingly difficult to treat. Cooperation of the family and of the employer in providing a suitable occupation goes far toward favoring recovery but unfortunately this is often impossible to secure.

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### BRAIN ABSCESS

#### (Suppurative Encephalitis)

The term "brain abscess" usually includes all intracranial abscesses which may be extradural subdural or intracerebral. Extradural abscess is not common but occurs when an inflammatory process of the skull, accessory nasal sinuses middle ear or mastoid is arrested by the dura so that pus accumulates between the bone and the dura. Subdural abscess begins as small areas of circumscribed meningitis but may extend over an entire hemisphere or even over a large part of both hemispheres. Ultimately, if no treatment is instituted the pus breaks through the limiting membrane and a purulent meningitis ensues. Intracerebral abscess may occur in any part of the brain and is usually secondary to inflammation of adjacent structures but the organism may be carried through the blood from a distant point of infection. These abscesses may be single or multiple.

**Etiology.**—The common etiological factors are (1) osteitis of the skull (2) fractures and gunshot wounds (3) inflammation of the accessory nasal sinuses middle ear or mastoid and (4) septicemia and pyemia sec-

ondary to inflammatory conditions in other parts of the body, particularly of the lungs and pleura.

The organism present varies greatly, but usually one of the common pyogenic types is found in smear or in culture. Gas forming organisms are occasionally found. Their presence is suspected by the escape from the wound caused by a compound skull fracture of thin, foul smelling pus and gas but the presence of the gas may be demonstrated in roentgenograms. In 1938 I reported two such cases with a review of the literature. The roentgenogram in one of these cases is shown in figure 134.

**Pathology.**—Extradural abscess occurs when thickening of the dura prevents the extension of pus beyond the membrane. As the pus accumulates the dura is separated from the skull. These abscesses are generally sessile. Occasionally the dura may remain attached to the skull except over a small area which slowly bulges into the cranial cavity active proliferation preventing rupture. The result is the formation of an abscess with a firm wall attached to the surrounding dura by a small stalk.

A small extradural accumulation of pus is an important stage in the formation of an intracerebral abscess. During this stage the dura becomes firmly adherent to the parietal and the underlying cerebral cortex is edematous. If the dura become necrotic there is an extension of pus into the edematous cortex followed by supuration. These changes in the meninges ultimately form the abscess stalk connecting the original site of infection with the intracerebral abscess. This therefore is an infection of the brain by direct extension from the primary focus. The direct connection may be absent when the infection has reached the brain through a blood vessel. Irrespective however of whether the infection reaches the brain by direct extension or through the circulation from nearby or distant foci the resultant reaction on the part of the brain is the same. This reaction consists of hyperemia with a varying amount of edema and a local red supuration (Fig. 135a). New capillaries are formed in the area with striking rapidity. From the blood vessel walls, fibrin casts wander into the field and are most important in the formation of the abscess wall which in the favorable cases entirely encircumscribes the inflammatory process (Fig. 136).

**Symptomatology.**—The signs and symptoms of brain abscess are first those of infection followed later by evidence of increased intracranial pressure. Headache is a very constant complaint and though it may be intermittent, is present in all stages. Vomiting is associated with the headache but varies with the degree of increased intracranial pressure except in the case of a cerebellar abscess in which it occurs as an

early irritative sign. The pulse rate during the early period is usually rapid but is almost invariably slow after the encapsulation of the abscess. Convulsive seizures are fre-

quently seen. The temperature range is likewise high during the first stage and low during the second. In the beginning cerebri-  
tion is slow and there is gradually increasing



Fig. 131.—Lateral view of the skull showing a small depressed fragment of bone (full thickness of skull) at A and a small large bubble of gas at B in an underlying abscess of the parietal lobe.

quent in the early period and may occur at any stage. They may be focal or general in type depending on the site of the lesion. The optic disks may show slight changes as

stupor leading to coma in the second stage. Delirium seldom occurs unless there is associated meningeal inflammation.

The clinical course of the disease there-



Fig. 133.—Superior view of the brain showing suppurative encephalitis before the period of abscess wall formation.

a result of cerebral edema in the early stage. In later stages a high grade choked disk with hemorrhages is the rule. Leukocytosis is present but disappears after complete en-

cephalitis. The disease may be divided into three stages: first, diffuse infection involving a limited area of the brain or brain and meninges with evidences of systemic infection—eleva-

tion of temperature rapid pulse and leukocytosis with or without focal neurological signs Headache and vomiting and frequently muscle twitchings and even convulsive seizures may occur The optic disks show little or no change Following the invasion the infection may spread rapidly through the brain or meninges or may be encapsulated The second stage that of encapsulation is afebrile and without other evidence of systemic infection Signs of increased intracranial pressure headache vomiting slow pulse choked disk and stupor with or without localizing signs depending on the location of the abscess characterize this stage In the third or terminal stage the abscess if untreated produces fatal

clinical evidence is in favor of a brain abscess and is only performed when there is reason to believe the inflammation is meningeal Serous meningitis can usually be differentiated from abscess by the absence of severe pressure symptoms in spite of an extreme degree of choked disk with impairment of vision The reason for the absence of pressure symptoms in cases of serous meningitis has never been satisfactorily explained but it is a fact that the patient does not have headaches in spite of the high cerebrospinal fluid pressure choked disk and loss of vision

Infective sinus thrombosis is characterized by intermittent fever chills general malaise prostration rapid pulse and restlessness



Fig 136—A completely encapsulated brain abscess Death resulted from increased intracranial pressure

pressure symptoms or the capsule ruptures with the escape of pus into the meninges ventricles or brain substance After the rupture the course is again a febrile one

Differential Diagnosis—The initial course of a brain abscess may be so similar to that of purulent meningitis that differentiation is often impossible during the first few days However the progress of symptoms in meningitis is much more rapid than in brain abscess In meningitis irritative signs predominate while even in the early stage of an abscess the cerebral edema in the neighborhood of the infection will probably produce some signs of pressure and as the condition approaches the second stage the pressure signs become much more marked Lumbar puncture should be avoided if the

During the afebrile phase the symptoms are slight or entirely absent Lumbar puncture and a Queckenstedt test may be necessary Gradenigo's syndrome is characteristic and should not be confused

Only the second stage of an abscess can be confused with that of a brain tumor The progress of symptoms in the case of an abscess is often much more rapid than in the case of a tumor A patient with a brain abscess usually gives a history of cerebral trauma or a primary focus of infection A ventriculogram may be necessary but is not without danger because of the tendency of abscesses to rupture into the ventricle or subarachnoid space

The history of recent trauma may make a differentiation between hemorrhage and

abscess necessary. Subdural hematoma with pressure symptoms some weeks after cerebral trauma may be very confusing. One must depend on the history and progress of symptoms but needle exploration through a small opening of the suspected area may be necessary.

**Treatment**—The sulfa drugs and penicillin are now valuable adjuncts in the treatment of brain abscess. The use of these drugs however has not greatly changed the incidence of brain abscess for in the course of infections of the ears, mastoids and accessory nasal sinuses and in osteomyelitis of the skull brain abscess develops in spite of the employment of these new drugs in treating the primary infection. Likewise metastatic abscesses of the brain still occur as the result of blood borne organisms particularly in suppurative lesions of the chest cavity. The use of the drugs in open wounds of the skull has doubtless diminished the number of brain abscesses following skull trauma. The work of Pilcher demonstrates however that care must be exercised in the use of these drugs within the cranium as they produce a certain amount of irritation. It is very improbable that the drugs have any influence upon the growth of organisms within the capsule of well walled off abscesses but in the early stage when the infection is diffuse or in any stage when there is spread to the meninges their value has been well demonstrated.

In spite of drugs abscesses must be allowed to encapsulate and then must be drained. Drainage can be accomplished through an opening 1 to 1.5 cm in diameter. Care should be exercised to avoid undue traumatization of the abscess wall. Through the opening a small blunt pointed cannula is passed in a search for the abscess. If pus is found the needle should be immediately withdrawn so that drains can be inserted into the distended cavity. The type of drainage material varies but most operators prefer one or more small rubber tubes. Two ordinary thin walled Carrel tubes which have been split along their entire length and made pointed at the end can be seized in a small bayonet forceps and pushed gently into the cavity. Pus will exude through and around the tubes and the cavity will be slowly evacuated. The tubes will remain in position without sutures. The skin wound is small and should not be sutured. The tubes should project about 1 cm from the outer surface of the wound and the dressings should be placed around these projecting ends thus avoiding pressure of the overlying dressings. If tubes are properly placed in the cavity and care is exercised in the dressing they will remain in place

until the suppuration ceases which may be several weeks. They are gradually shortened after the first four weeks by cutting a few millimeters from the outer end of the tube. By this method there is a minimum scar at the site of the abscess.

Mosher for many years has successfully used a wire gauze mesh tube. King advised unroofing the abscess by removing the bone and cortex overlying it. Danly prefers a simple aspiration on which it is a matter of more aspirations being necessary.

Complete removal of the abscess is possible only in exceptional cases and should not be undertaken as a routine measure.

**Prognosis**—The prognosis in a case of brain abscess depends on the location of the lesion and the type and virulence of the causative organism. Multiple abscesses are uncommon and very difficult to cure. Abscess of the temporal lobe secondary to otitis media is the most favorable while abscess in the frontal lobe offer a greater problem in drainage and are less favorable. Cerebellar abscesses drain well but the rapid progress of the condition often produces serious and even fatal disturbance of the brain stem before encapsulation occurs. Deep seated abscesses are often difficult to drain offering a poor prognosis. A superficial lesion at the site of a depressed fracture is favorable because proliferation of the indurated remnants of the dura often produces firm encapsulation. Intracranial extension of infection in osteomyelitis of the skull still remains a serious lesion in spite of the favorable influence of sulfa drugs and penicillin.

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## TUMORS OF THE BRAIN

Tumors of the brain which for practical purposes include all intracranial new growths are far more common than is generally realized. They constitute nearly 2 per cent of all tumors found at operation or autopsy. It is seldom realized that tumors of the brain are much more common than cancer of the stomach and that the prognosis on the whole is better. In fact many intracranial new growths can be treated by modern neurosurgical methods more successfully than can most of the tumors found elsewhere. Early diagnosis will greatly increase this favorable percentage.

Brain tumors may be roughly classified as follows: those arising from the coverings of the brain such as the dural meningioma; those developing in or on the cranial nerves best exemplified by the acoustic neuroma and the optic nerve spongioblastoma; and those originating in the brain tissue as the various gliomas, sarcoma, tuberculoma, gumma and metastatic lesions.

**Symptoms.**—The symptomatology is exceedingly variable and depends on a number of factors: the chief of which are the location, extent, rate of growth and type of tumor. The so-called classical symptoms are simply those of increased intracranial pressure and may or may not be related to the factors just listed. These symptoms of slowly increasing intracranial pressure are in the usual order of sequence: headache, nausea, vomiting and visual disturbances. Focal symptoms with or without evidence of increased pressure may be present depending on the location of the tumor. These may consist of jacksonian epileptic attacks, weakness or paralysis. Mental change may be the initial symptom and in a lesion in the

frontal lobe may predominate throughout the course of the disease.

The headache is of little localizing value in the case of a cerebral tumor but in a cerebellar lesion the headache is predominantly low occipital. There may be also frontal headache associated with the pain at the back of the head and upper part of the neck. A tumor above the tentorium irrespective of its location frequently produces bilateral frontal headache. The pain accompanying a parietal or temporal lobe tumor occurs somewhat more frequently on the side of the lesion but the incidence is not sufficiently high to be of definite localizing value. The headache is usually described as dull throbbing in character lasting for hours and occurring almost daily. Some patients complain of practically continuous headache which varies in intensity. Bending over or exertion may greatly intensify the pain. As a rule the headache is not relieved by vomiting.

Nausea and vomiting are a comparatively late manifestation of a brain tumor and always indicate an increase in the intracranial pressure. These gastric symptoms when not easily explained otherwise should always raise the suspicion of an intracranial tumor. This is particularly true in children in whom nausea and vomiting lasting more than two or three days is almost always due to increased intracranial pressure. It is surprising how frequently this possibility is overlooked and the tonsils and appendix although otherwise symptom free are removed in the hope of giving relief. Nausea may not be followed by vomiting in the early cases but as the pressure increases vomiting without nausea is frequently noted. At first there is no distinction between vomiting due to increased intracranial pressure and that from other causes but later it may appear without warning and become so forceful that a diagnosis of increased intracranial pressure can be made. This latter type of vomiting is spoken of as projectile and not infrequently the expulsive force is so great and appears with such suddenness that the vomitus will be thrown a distance of several feet sometimes to the great embarrassment of the patient. It must be emphasized however that projectile vomiting is a relatively late symptom.

vomiting is frequently associated with brain tumors

*Visual disturbances* are of two types a general diminution in visual acuity and a loss in some part of the visual field. The first is the result of increased intracranial pressure causing edema of the optic nerve head from partial venous obstruction. As the swelling of the nerve head progresses it is pushed out farther and farther into the eyeball the actual distance being measured in diopters with the ophthalmoscope. The swelling of the nerve head obliterates the normal cup and the resulting appearance has been designated as *choked disk*. The obstruction of venous return may also produce widespread retinal hemorrhages. Visual acuity is not entirely dependent on the number of diopters of swelling but rather on the shape assumed. The mushroom type of choked disk causes early visual loss while the cone shaped although measured as more diopters of swelling may not seriously interfere with vision. After long continued choking of the disks the swelling gradually disappears leaving a yellowish white disk indicative of secondary optic atrophy. When this appears hopes for much restoration of vision are nil. For this reason alone careful ophthalmologic examinations should be made and repeated at frequent intervals for every patient suspected of having a brain tumor.

*Defects in the visual field* occur with tumors of the temporal and occipital lobes from pressure on or destruction of the optic radiations and in tumors of the pituitary body or adjacent regions producing direct pressure on the optic nerves or tracts. Pituitary tumors commonly press upward in the midline stretching the crossed fibers of the optic chiasm. This produces blindness in the lateral half of the visual field for each eye and is called bitemporal hemianopsia. Pressure on one of the optic tracts posterior to the chiasm or a tumor in the temporal or occipital pole may produce blindness in the lateral half of the temporal field of one eye and the inner half or nasal field of the opposite eye. This is called an homonymous hemianopsia and the lesion is always located on the side opposite the blindness. This type of blindness is frequently unnoticed until an automobile accident results from failure to see cars approaching from one side.

The *mental symptoms* are usually characterized by a change in personality forgetfulness irritability without evident cause difficulty in concentration somnolence and in the more advanced cases slovenliness some times to the point of complete disregard of the usual personal habits. Many patients show great emotional instability characterized by either undue laughing or crying. Marked facetiousness is a frequent symptom in prefrontal lobe tumors.

*Diagnosis*—The diagnosis of a brain tumor and even its exact location are not considered sufficient. In addition it is desirable to know preoperatively the type of tumor likely to be encountered so that the best surgical procedure can be planned. It is therefore essential for the neurosurgeon to be familiar with the natural history symptoms and location which to a surprising extent are characteristic of the various intracranial tumors.

*Ventriculography* is the most valuable single diagnostic aid in the detection and localization of brain tumors at the surgeon's command. Its routine use is not recommended for every case of suspected brain tumor but it should be performed whenever the evidence of such a lesion is rather definite and a positive diagnosis or exact localization cannot be made on the neurological findings and the routine roentgen examination. There is probably a mortality rate of not more than 1 or 2 per cent which can be honestly attributed to this procedure. For a strictly diagnostic procedure this may appear prohibitive. It must be remembered that practically every patient with a brain tumor will die unless he is successfully operated on. Therefore any diagnostic procedure which will be of material value in making possible the successful extirpation of an otherwise hopeless lesion even though there is some risk involved is justifiable.

Two locations for the skull openings are common. The first is located about 1½ inches above and an equal distance behind the top of the ear. The second is made about 1¼ inches above the occipital ridge and an equal distance from the midline. The writer prefers the lateral approach. In the majority of cases a single trephine opening is sufficient. This is generally made on the right side. The scalp is infiltrated with a local anesthetic and a vertical incision about 2 inches long is made through scalp aponeurosis and pericranium. The larger blood vessels are caught with

hemostats and a small self retaining mastoid retractor is used to hold the incision apart. The skull is perforated with the Hudson burr and a small incision made in the dura. A ventricular needle is then carefully passed medially into the ventricle. The ependymal lining of the latter offers slight resistance to the passage of the needle generally indicating that the ventricle has been reached and that the obturator can be withdrawn. The normal ventricle lies about 4 or 5 cm. from the scalp. By this lateral approach the ventricle is entered at the junction of the posterior and descending horns with the body of the ventricle. An adapter fitted to a short length of rubber tubing is instantly attached to the ventricular needle, the tubing slipped on to a graduated glass manometer and the pressure of the fluid noted. While this is not an essential part of the technique the data obtained are frequently useful. If the pressure is high the fluid should not be evacuated rapidly. Instead, a small amount of fluid should be allowed to escape, the tubing should then be pinched for a moment and the process repeated. A too rapid reduction in ventricular pressure may cause petechial hemorrhages in the ventricular wall. Air or oxygen is then slowly injected into the ventricle. The writer prefers oxygen because it is more rapidly absorbed. Since using oxygen it has not been necessary to tap the ventricle to relieve rapidly developing pressure symptoms, a common occurrence when air is used. The oxygen is injected in amounts of from 5 to 10 cc., an equal quantity of fluid being withdrawn before each injection. At the completion of the procedure, the intraventricular pressure should be atmospheric. Occasionally it is impossible to withdraw more than 1 or 2 cc. of fluid because of ventricular collapse. In such cases it is justifiable to inject first 3 or 4 cc. of oxygen and then disconnect the syringe allowing fluid to be forced out. Quite satisfactory filling of the ventricles can sometimes be obtained by this method.

The patient's head rests on the occiput with the face upward during the initial filling of the ventricle. When no more fluid can be obtained the occiput is elevated and the head turned from right to left several times. This allows the gas to pass into the third and opposite lateral ventricles. An attempt should always be made to fill one ventricle completely and at least part of the opposite one. Many errors in the interpretation of ventriculograms are due to incomplete filling. The scalp incision is closed in layers and roentgenograms of the head are made in several positions.

*Encephalograms* are made by the injection of air through a lumbar puncture needle with the patient in a sitting position. By this procedure, the subarachnoid space is filled with air, and obstructions in the cerebrospinal fluid pathways over the cortex and in the various cisternae can be diagnosed in most cases. As a rule, the ventricles are not as well filled as in the previous procedure. Encephalography is a very useful diagnostic aid in the detection and localization of small tumors, especially those involving the cortex.

However, it is a very dangerous procedure in the presence of increased intracranial pressure and should never be used when choking of the optic disks is present.

The determination of the *spinal fluid pressure* by means of a water manometer attached to the lumbar puncture needle may be of considerable value as corroborative evidence toward the diagnosis of a brain tumor. The fluid should never be withdrawn rapidly, as in the ordinary routine lumbar puncture for diagnostic purposes since in the presence of increased intracranial pressure, the tonsils of the cerebellum may already be wedged downward through the foramen magnum, and the sudden relief of pressure from below may cause still further dislocation. This may produce sudden pressure on the medulla with resulting respiratory failure. In the presence of choked disk no fluid should be withdrawn by lumbar puncture. However, at times, chemical examination or a cell count is of great importance, but not more than 5 cc. should be withdrawn for these tests.

#### TREATMENT

**Anesthesia for Intracranial Operations.**—The type of anesthetic used for intracranial operations is of the utmost importance. Ether, chloroform, nitrous oxide and ethylene all raise the intracranial pressure and make the operation correspondingly more difficult. The last two also increase bleeding and cause cerebral congestion. Avertin (tribromethylalcohol) and local anesthesia do not have this drawback and certainly are the preferable anesthetics to be used during the removal of brain tumors. Most operations of this type are of relatively long duration and a local anesthetic unless distinctly indicated does not seem desirable either for the patients or the surgeon's equanimity. Avertin produces excellent narcosis. There is no preliminary excitement stage and postoperative nausea and vomiting are reduced to a minimum. The incidence of postoperative pneumonia is also greatly reduced. The dose used varies in different clinics from 60 to 110 mg. per kilo of body weight. The author prefers the larger dose except in very debilitated patients and has seen no harm resulting. With the smaller amounts it is frequently necessary to supplement with ether. While the amount of ether required may be relatively small it may be sufficient to produce some increase in intracranial pressure. A local anesthetic used prior to the administration of the avertin is highly recommended by some surgeons and is of benefit in allowing the use of smaller doses of avertin. Occasionally even when 110 mg. per kilo is used supplementary ether anesthesia is required. As a rule, however, this can be discontinued as soon as the osteoplastic flap is reflected.

**Supportive Measures During Intracranial Operations.**—The continuous administration of normal

salt solution or a per cent glucose during the course of a prolonged intracranial procedure may be of great benefit in preventing shock and certainly lessens the necessity for transfusions either during the operation or immediately thereafter. The salt solution or glucose may be administered intravenously or per rectum. If during the course of the operation the blood pressure suddenly drops from 50 to 100 cc of 50 per cent glucose can be given intravenously with in most cases very satisfactory results. Citrated blood may be administered. Caffeine sodium benzoate administered subcutaneously or intravenously appears to be a useful stimulant and some believe that it helps reduce the intracranial pressure. If these supporting measures do not have the desired effect or if there is undue delay in obtaining blood for transfusion the patient's head may be lowered but this definitely increases venous bleeding and should be resorted to only in dire necessity. It is to minimize venous bleeding that practically

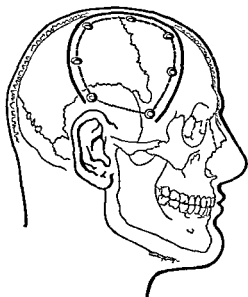


Fig 137—Osteoplastic craniotomy for parietal lobe tumor. The heavy black line is the scalp incision. The broken line represents the bone flap.

all intracranial operations are performed with the head at a higher level than the body. This reduction in venous pressure has led some neurosurgeons to advocate the sitting position for all cerebellar operations.

**General Principles of Cranial Operations.**—Certain general principles in neurosurgical technique are applicable to practically all cranial operations. These are outlining the scalp flap, control of bleeding during the initial incision and after the scalp flap has been completed, the perforation of the skull and the sawing between these perforations, the prevention of bleeding from the bone, dural vessels and great sinuses, opening of the dura, control of cortical vessels, protection of the brain from trauma and incision of the cortex.

All scalp incisions should first be outlined with a scratch mark before the operative site is draped since the latter may hide important landmarks. Cross scratches at suitable intervals are made along the proposed line of incision so accurate approximation of the

scalp edges may be assured at the completion of the operation. A curve is always preferable to a sharp angle since the blood supply may be impaired by the latter. Even in curved incisions there is sometimes slight sloughing at the corners of the scalp flap. The base of the flap is usually much smaller than the upper portion but it should be sufficiently wide to insure adequate blood supply. When possible, the base should be so placed as to include a large vessel such as the temporal artery. Ordinarily the base of the flap is made just above or in front of the ear. This not only insures an adequate blood supply but the bone is broken where it is relatively thin. The bone flap is usually hinged by the temporal muscle.

**Hemostasis** during the initial incision is best accomplished by digital compression. One or two assistants place their finger tips close to each side of the scratch mark and maintain firm pressure as the incision is carried entirely through the scalp. Fine-pointed hemostats are placed on the edge of the galea at frequent intervals usually from 1 to 2 cm apart. These are reflected to either side, rolling the galea against the cut edge of the scalp, thus compressing the small vessels. Hemostats are never placed directly on the scalp since it is easily crushed and subsequent healing might be dangerously delayed. A gauze sponge is laid along the edge of the scalp and the hemostats are laid over this and then tied together in groups of four or five. Usually a towel is draped over the hemostats to keep them in place during the course of the intracranial procedure. Instead of hemostats a special large skin clip can be used approximating the galea and the upper surface of the scalp. These are especially useful on the flap.

The *scalp flap* including the pericranium is carefully stripped from the bone and turned downward at the base. However, the attachment of the temporal muscle is not loosened. Removing the pericranium from the bone flap does not seriously impair the nutrition of the latter but does materially reduce bleeding from the bone. This is a very important factor since slow bleeding from minute points on the inner side of the bone flap is sometimes a very serious postoperative complication. Small bleeding points on the inner surface of the pericranium and larger vessels on the edge of the scalp may be gently desiccated with the electric current. Care should be exercised to shrink only the vessel at its bleeding point and not damage the adjacent tissue.

The *skull* is usually perforated with a Hudson burr using a hand brace. Some prefer an electrically driven drill but the latter is not much faster except in a very thick skull. The author prefers a diamond shaped tip for the initial perforation, the drill opening being enlarged by the second and third size Hudson burrs. The fourth size is scarcely ever used. Bleeding from the bone is controlled with Horsley's bone wax. This is pressed into the bleeding points and the excess scraped away with a penosteal elevator or wiped away with gauze. Small bleeding points on the dura may be desiccated with the electric current or temporarily controlled with a cotton pledget. After the entire series of drill openings has been made the dura is carefully freed from the bone about each opening and a Gigli saw carrier which also acts as a dural protector is passed between two holes. A Gigli saw is drawn through

and the bone cut on a bevel slanting outward. Frequent irrigation with salt solution facilitates cutting and keeps the saw cool. Bleeding from a saw cut cannot be controlled until after the osteoplastic flap has been reflected. For this reason a known vascular area in the skull is cut last. To facilitate breaking the bone at the base, a narrow channel may be cut for a centimeter or two medially between each of the lower two drill openings. This channel may be cut with very narrow bladed rongeurs or with a DeVilbiss forceps. The author prefers passing the High saw guide between the two drill openings and cutting a groove in the inner surface of the bone. This can be readily done without damaging the overlying temporal muscle by holding the saw nearly horizontal. No attempt is made to divide the bone completely, a comparatively shallow groove being sufficient. Flat elevators are placed through the two upper drill openings and the bone flap pried upward until it fractures across the bone. All bleeding points on the bone edges are controlled with wax. Bleeding from the under surface of the bone may be quite marked and is controlled by wiping wax into the small perforations and along the channels of the middle meningeal artery. Control of these bleeding points is often facilitated by desiccating them with a much stronger current than is used on the scalp or dura. The bone flap is then covered with gauze to prevent the bone from becoming unduly dry.

Small bleeding points on the surface of the dura are easily controlled by light desiccation. The middle meningeal artery is divided near the base of the flap and silver clips are applied to the cut ends. Bleeding from large pachionian granulations and from the great sinuses may be controlled by delicate coagulation. Frequently, however, this is not sufficient and thin pieces of crushed muscle should be used. There is considerable danger of rupturing a sinus when attempting to desiccate it. There is also the danger of too great thrombosis with blockage of the sinus. For these reasons it is believed that application of small muscle grafts is preferable. These are firmly pressed against the bleeding points usually by a piece of moist cotton. After a few minutes the muscle will adhere quite strongly to the surface of the dura or sinus. Occasionally it is necessary to divide one of the great sinuses such as the superior longitudinal or the lateral. An unusual difficulty at once presents itself as these large vessels are held open by traction in three directions. In the case of the superior longitudinal the dura pulls laterally on both sides and the falx pulls it downward. When it is necessary to divide such a sinus the dura is opened on both sides up to the vessel. A hemostat can then be placed across the vessel and adjacent portion of the falx or in the case of the lateral sinus onto the tentorium. Division is made between the two hemostats. The vessels can then be closed by a continuous suture of fine silk or the falx can be cut close to and parallel with the sinus and the vein then ligated in the ordinary manner. Occasionally a plug of muscle can be forced into a small opening in the sinus without ligation of the vessel and with the possibility that its lumen will not be completely obliterated. The large veins in the falx and tentorium as well as those encountered in the dura lateral to the longitudinal sinus are most readily controlled by cutting the dura and applying silver clips to all bleeding points. In case one

does not wish to cut the dura or its extensions the large veins may be controlled by very gentle desiccation using a ball tip and a light current. Muscle grafts may also be used.

The dura is opened in the following manner. A small sharp hook is caught into the dura and the latter elevated. Incision is made through the dura as it is held away from the underlying cortex. It is then grasped

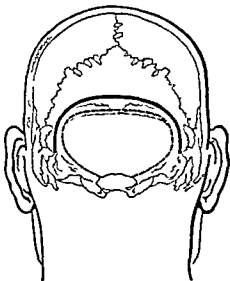


Fig. 138—The approach used for a cerebellar tumor

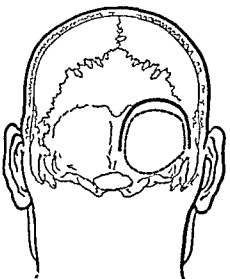


Fig. 139—The approach used for an acoustic neurinoma

with fine-toothed thumb forceps and held up as the dural flap is cut with round-pointed scissors. Many surgeons prefer passing a grooved director through the initial opening and then cutting along the grooved director with a sharp knife. This can be done very rapidly, the director being moved forward with the knife held stationary against it. The flap of dura may be turned in any direction but preferably anteriorly or posteriorly as this allows for decompression in-

feriorly, that is beneath the temporal muscle and the control of the superior dural veins with silver clips.

The cortex must be handled with greatest care. Gauze sponges should never be used. Cotton pledgets are used for sponging and many prefer these moistened in saline. Small bleeding vessels of the cortex may frequently be controlled by light pressure with a cotton

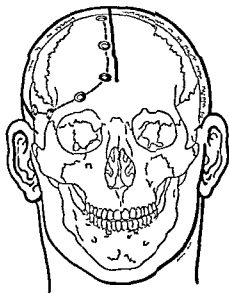


Fig 140—Approach for pituitary, suprasellar and frontal lobe tumors

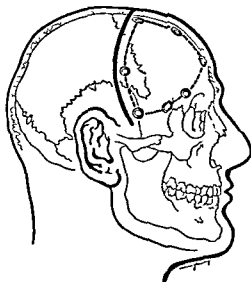


Fig 141—Lateral view of the approach shown in figure 140

pledget. They also may be desiccated using a very light current so as not to shrink surrounding tissue. Occasionally a small muscle graft may be necessary. Silver clips are applied only to cortical vessels which are to be divided. The brain should be kept moist at all times. This can be accomplished by protecting the brain beyond the tumor with moistened strips of sheet cotton. Frequent irrigations of the exposed brain with

normal salt or Ringer's solution is advisable. Incisions whenever possible should be placed so as not to cross large cortical vessels. Vessels which must be divided no matter how small should first be either desiccated or ligated with fine silk, carried on a curved needle or crushed with silver clips. Subcortical vessels are generally controlled with silver clips. Incision through the cortex and deeper layers of the brain may be made either with a scalpel or an electric knife. The writer prefers the latter. When a considerable area of cortex is to be excised to expose a tumor adequately the electric loop is especially useful. With this instrument, long thin strips of brain tissue may be removed rapidly and with a minimum of bleeding. The current must be adjusted for the particular type of tissue being cut. Very edematous or softened brain requires considerably greater dehydration.

Two methods of exposing a deeply situated tumor are commonly used. The first consists of a single incision carried through all layers down to the tumor with careful retraction of the cut edges. The second and probably preferable method except in the Rolandic area is to uncap the tumor by removal of cortex and deeper portions of the brain over a sufficiently large area to give adequate exposure. Occasionally a tumor can be best treated by excising a lobe of the brain. This is comparatively simple in the frontal region as it is necessary only to doubly clip or desiccate and divide the veins passing from the frontal lobe to the longitudinal sinus and dura and to clip the vessels on the surface along the posterior border of the proposed excision. The brain is then incised vertically just anterior to this line and the few deeper vessels are clipped as they are encountered. The occipital pole may be excised in a similar manner. The writer generally prefers removing the temporal lobe piecemeal with the electric loop.

Continuous suction should be available throughout all brain operations. If a small metal sucker is used sponging is rarely necessary and an enormous amount of trauma may be thus prevented. Small bleeding vessels are caught in the end of the sucker and then clipped or the desiccating current may be applied directly to the instrument and coagulation takes place while the field is kept dry. A pledget of moistened cotton placed at the end of the metal sucker will still allow a moderate amount of suction and prevent damage to adjacent brain tissue, choroid plexus or nerves. This use of a cotton pledget is only applicable when the bleeding vessels are very small or when only cerebrospinal fluid is being removed. The small sucker generally used has a diameter of about 2 mm. A slightly larger one (3 mm lumen) is necessary at times. Very soft brain tumors as the glioblastomas may be largely removed by suction. For this purpose a glass tube similar in size to the ordinary drinking tube is very serviceable.

The dura is closed with interrupted fine silk sutures placed about a centimeter apart. It is left open beneath the temporal muscle when a decompression is considered necessary. However if the dura is infiltrated with tumor cells as occurs in practically every meningioma and in some gliomas this portion of the dura must be excised. Various means of repairing the defect have been advocated. Some split the remaining dura into two layers and use the outer layer as a graft over

the defect. Others use a piece of fascia lata. Cargile membrane has also been recommended. The author, after a very extensive experience, now makes no attempt to fill in a dural defect and has seen no harm resulting from contact of the brain with the bone. A pseudodura rapidly forms from wandering cells originating in the normal dura, and at a subsequent operation it is sometimes difficult to determine which is the original and which the new-formed brain covering. The osteoplastic flap is then returned to position and if the original drill openings were properly placed making a key-stone shaped bone flap and the Gigh saw cuts have been made with the proper bevel, the bone flap will remain securely in position. In the very thin skulls of children or where bone has been rongeuired away to expose a tumor further, one or more steel wires placed through drill openings in the skull and flap may be used to hold it in place. Occasionally the bone flap is completely removed either because it has been extensively involved by the tumor or where a much

The commonest site is along the superior longitudinal sinus, but they may develop on any portion of the dura, falx or tentorium. Because of their usually slow, non-infiltrative growth, the brain is slowly indented. The first symptom of the very common parasagittal meningioma is often sensory or motor jacksonian attacks, starting in the leg, since this cortical area is nearest the midline. This may be followed by weakness of the leg, arm and face in order. Generalized epilepsy is frequent with all types of meningioma. Because the growth is slow and there is usually no block of the ventricular system, intracranial pressure does not increase until edema of the brain develops from interfer-

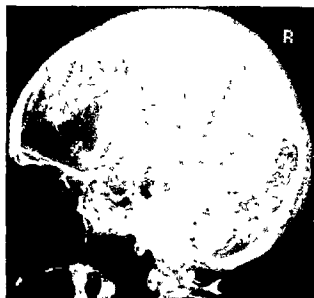


Fig. 142—Hyperostosis from meningioma of tuberculum sellae

greater decompression is considered necessary than would be obtained by a subtemporal decompression. Under such circumstances the dura is only covered with the scalp flap. The incision is closed by careful painstaking approximation of the edges of the galea using fine silk sutures placed about 1 cm. apart. The scalp is then closed with interrupted silk sutures.

#### MENTINGIONIA

The meningiomas represent about 18 per cent of intracranial tumors. Though ordinarily benign they may become sarcomatous and display a tendency to rapid recurrence. These tumors take their origin from arachnoidal cell clusters and so are most frequent in those areas where the arachnoidal granulations are most abundant.

The meningioma is a tumor of adult life.

ence with the venous return. Consequently choked disk is generally a late sign.

Meningiomas may arise from the cribriform plate producing the syndrome of the olfactory groove. This consists of anosmia and primary optic atrophy, perhaps associated with mental symptoms from frontal lobe involvement. The sella may be normal, but the roentgenogram frequently reveals an enostosis just posterior to the cribriform plate.

Meningiomas of the sphenoidal ridge tend to be flat and produce marked bony overgrowth. The symptoms usually indicate a temporal lobe tumor. A unilateral exophthalmos with swelling of the temporal region may occur. Meningioma of the tuberculum

cellae may be suspected when bitemporal hemianopsia and primary atrophy are noted and the roentgenogram reveals a normal sella. Meningioma is uncommon in the posterior fossa.

Meningiomas are fairly frequently calcified but more important is the bony change in the overlying skull. This may consist of a markedly vascular erosion. The flat spreading type of meningioma tends to produce marked bony overgrowth with formation of enostoses or diffuse thickening. A unilateral enlargement of the groove for the middle meningeal artery suggests the presence of an underlying tumor.

The commonest type of meningioma has a tough connective tissue capsule over which course many blood vessels. The tumor is usually adherent to the overlying dura. It may deeply indent but rarely infiltrates the brain substance. Incision into the tumor reveals a firm granular grayish tissue that is sometimes extremely vascular. Microscopically characteristic are cells with abundant cytoplasm massed into whorls. The central cells of the whorls may undergo hyaline degeneration and become calcified producing the psammoma bodies.

Complete excision of the tumor and the infiltrated dura and bone is indicated in practically all cases. The tumor may be removed intact or excised piecemeal with the electric loop. The prognosis is usually favorable.

#### ACOUSTIC NEURINOMA

The acoustic neurinoma is a slow growing encapsulated tumor arising from the neurolemma of the vestibular portion of the eighth nerve within the porus acusticus. As it expands medially it reaches the cerebellopontine angle and produces a typical syndrome namely unilateral cerebellar involvement with homolateral cranial nerve palsies from the fifth nerve downward.

The first symptom is tinnitus which is followed by progressive loss of hearing. As the fifth nerve is encroached on there develops a loss of the corneal reflex. Later pain characteristic of the douloureux and numbness of the face may appear. As the seventh nerve is stretched a slight peripheral type of facial palsy may be demonstrable. Later disturbance in swallowing and unilateral laryngeal paralysis develop owing to vagus

involvement. Only when the tumor is large enough to obstruct the flow of cerebrospinal fluid does choked disk appear. In the early stages of the tumor tinnitus, loss of hearing, and dizziness suggest Meniere's disease. Pontine tumors with unilateral cranial nerve palsies may cause difficulty in diagnosis. Choked disk is usually absent here and when a third nerve palsy appears acute neurinoma is ruled out. Meningiomas in the region of the cerebellopontine angle may suggest acoustic tumor but the surgical approach is the same for both. A sign pathognomonic of acoustic neurinoma is unilateral enlargement of the porus acusticus as demonstrated by the roentgenogram.

The surgical procedure and the gross appearance of the tumor are described with the technique of unilateral cerebellar exposure for acoustic neurinomas and other angle tumors.

Microscopically the acoustic neurinomas consist of two main cell types (Antoni). 1. Spindle cells arranged in whorls with frequent palisade alignment of the nuclei; these areas are very rich in fibrillae which can be readily stained by reticulum connective tissue stains (Papanicolaou, Mallory). 2. Reticulated tissue showing a syncytial protoplasmic network containing round and oval nuclei of various sizes. Secondary degenerative changes are very common in the neurinomas as hyalinization, fatty degeneration and at times a pseudonodular degeneration sometimes leading to cyst formation.

The prognosis is good if extirpation is complete.

#### GLIOMA

The glioma is represented over 40 per cent of all brain tumors. They have been classified histologically into ten groups by Bailey, the more common of which produce syndromes. The more common gliomas are the medulloblastoma, the astrocytoma, the glioblastoma, the ependymoma and the oligodendroglioma.

**Medulloblastoma**—The name "medulloblastoma" was given by Bailey in 1923 to a group of gliomas arising almost invariably in the roof of the fourth ventricle. They occur most frequently in children between the ages of eight and twelve rarely in adults. The tumor, because of its rapid growth and position within the fourth ventricle, quickly obstructs the outflow of cerebrospinal fluid.



The symptoms may consequently develop with great rapidity.

**Symptoms**—The earliest symptom is usually difficulty in walking and a growing tendency to stumble and fall. The child walks with a wide base. Headaches, nausea and vomiting soon follow or may even precede the difficulties in locomotion. Soon the child staggers and reels and walking unassisted may be impossible. Dimness of vision is noted. The ataxia is ordinarily more marked in the legs than in the upper extremities. Choked disk develops early and is often of the acute type with multiple small hemorrhages at the margin.

Microscopically the tumor consists of groups of cells resembling lymphosarcoma with a deep staining nucleus and little cytoplasm. The medulloblastoma cell has a tendency to spread through the subarachnoid space and set up implantation metastases. Consequently the entire cerebro-spinal axis is irradiated postoperatively. Unfortunately however within two years the tumor usually becomes refractive to x-rays and death results. A few patients have lived for five years.

**Astrocytoma**—The astrocytomas are the commonest of the gliomas. Clinically they may be divided into three groups: (1) the

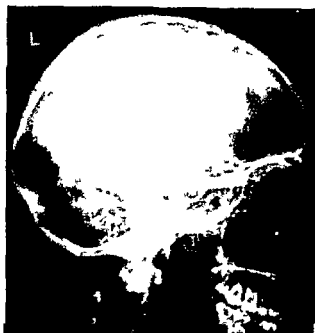


Fig. 113—Calcified glioma

**Pathology**—The appearance of a medulloblastoma at operation is quite characteristic. The vermis is broader than normal and when the tonsils are separated a grayish tumor is seen extending from the fourth ventricle. When the vermis is incised the tumor is found to fill the fourth ventricle more or less completely though frequently only infiltrates the roof. The tumor is usually soft and may be quite vascular. Complete excision is rarely possible and the present practice is to excise only sufficient tumor to establish ventricular drainage. A large cerebellar decompression is made and later x-ray therapy administered. It is the most radiosensitive of all the gliomas.

cystic astrocytoma of the cerebellum usually manifesting itself in childhood; (2) the cystic astrocytoma of the cerebral hemisphere frequently calcified appearing in adult life; and (3) the infiltrating often rapidly growing astrocytoma of children and young adults which sometimes invades both cerebral hemispheres.

The cerebellar astrocytoma of childhood is a slow growing relatively benign lesion and constitutes about 50 per cent of the supratentorial tumors in children. It usually develops in one hemisphere and only rarely crosses the midline. The increase in intracranial pressure due to obstructive hydrocephalus usually manifests itself before the

age of twelve. Consequently separation of the suture lines and convolutional atrophy can be frequently demonstrated in roent-

differential diagnosis usually can be made from medulloblastoma because of the longer duration of symptoms in the astrocytoma



Fig. 144—Astrocytoma of right temporal lobe. The demyelination and deeply infiltrative growth of the tumor are seen.

genograms. Some enlargement of the head with cracked pot sound on percussion may be present. Ataxia and dysmetria signs of cerebellar dysfunction are more marked in the upper extremity than the lower and

Cerebellar astrocytomas in adults are also the most benign of all tumors occurring below the tentorium with the possible exception of the meningiomas and the acoustic tumors. The results in these latter neoplasms



Fig. 145—Ventriculogram showing dilated lateral and third ventricles, supratentorial tumor.

occur on the side of the hemisphere involved. The gait may be typically 'cerebellar' with the toes turned out on the side of the lesion to prevent falling in that direction. Choked disks of long duration frequently with secondary optic atrophy are noted. A

are on the whole not as good since the tumors are frequently very large before they are detected and in the case of the acoustic tumor recurrence is much more frequent. The tumors are frequently cystic with simply a nubbin of astrocytoma in the lateral wall

The tumor originates in one or the other cerebellar hemisphere and does not as a rule involve the midline structures although because of its unilateral placement it often displaces the vermis to the opposite side.

The surgical approach is usually lateral since only occasionally can one be certain as to which side contains the tumor. In such cases the intracranial approach is preferable for acoustic tumors but with the latter in the bone carried to or slightly across the midline is entirely satisfactory. After the dura is opened a yellowish walled cyst may be discernible on the surface of the cerebellum. When the cyst is more deeply placed there may be no visible evidence of its presence. However the smaller surface vessels are usually collapsed giving a whitish or pale yellowish appearance and the surface markings are largely obliterated. By gentle palpation on a level just above the cerebellum the cyst can frequently be detected. A ventricular needle can be passed into the cerebellum in various directions and the cyst located in that way. Frequently the location of the more solid portion of the tumor is detected by the resistance felt on the passage of the needle. If the cyst is superficial the cerebral vessels are less cut and the cyst is opened easily allowing the evacuation of yellowish serous fluid. When it is more deeply placed the overlying cortex is removed with the electric loop until the cyst is opened and the typical yellowish serous fluid evacuated. The inner surface of the cyst wall is examined for the nubbins of astrocytoma which is practically always present. When it is located its extent is determined and a wide excision made about the tumor. All vessels being either desiccated or divided between silver clips. This method of dealing with the tumor by which the latter is removed intact, is preferable to piecemeal excision. However the latter is sometimes necessary especially when no cyst is present and the location of the astrocytoma can only be readily determined. These tumors often extend to the midline but rarely involve the walls of the fourth ventricle or the vermis. The prognosis is excellent.

*Cystic astrocytomas* in the cerebrum are usually found in young adults. There is frequently a history of jacksonian epileptic attacks for several years. Headaches vomiting and visual disturbances are relatively late symptoms. The tumor may develop in any portion of the cerebrum but is found most frequently in the frontal and parietal regions. It is very slow growing and an enormous cyst is sometimes found in a patient presenting few symptoms.

The treatment is entirely surgical. An osteoplastic flap is reflected and the region of the tumor exposed. The cyst may extend to the surface of the cortex or may be more deeply situated. In the latter case it is located with an exploring needle and the yellowish fluid evacuated. The cyst is then

opened widely a transcortical or local incision being made when the location is deeply situated. A nubbins of relatively solid tumor is usually found arising in the cyst wall. This is completely excised preferably with the electric knife. The remainder of the cyst wall does not require excision as the nubbins usually constitutes the entire tumor. The prognosis is excellent although in those who have had epileptic attacks for years occasional attacks may be expected.

*The infiltrating rapidly growing astrocytoma* of the hemisphere carries a hopeless prognosis. This type is seen in children as well as young adults. Grossly the tumor tissue except for increased resistance cannot be differentiated from the normal white substance. It frequently infiltrates deeply into the basal ganglia and not rarely involves the opposite hemisphere. Complete surgical removal is impossible while x-ray treatment in no way retards the growth.

Microscopically the cystic types of astrocytoma show a feltwork of fibrillae with scattered nuclei and are composed almost entirely of fibrillary astrocytes. The infiltrating rapidly spreading astrocytoma is composed chiefly of protoplasmic astrocytes which show more evidence of growth. In Weigert sections the advance of the neoplastic cells with demyelination of the axon cylinders can be well seen.

*Glioblastoma Multiforme.*—This tumor was first described in 1924 by Globus and Strauss as spongioblastoma multiforme and is the most rapidly fatal of the glioma group. It usually involves the cerebral hemispheres in middle age. After the onset of the first symptom there is a rapidly progressive downhill course. Necrosis and minor hemorrhage frequently occur in and around the tumor giving rise to sudden paralysis making a differential diagnosis from vascular disease difficult. Choked disk is sometimes absent adding to the difficulties of diagnosis. The symptoms are usually fulminating headache mental changes and paralysis rapidly appearing.

The tumor is almost invariably subcortical and is usually located at operation by palpation which reveals an area of abnormal softening. When the overlying brain substance has been excised a vascular mass of varied appearance and consistencies is en-

countered Gelatinous as well as necrotic yellowish or grayish green areas are seen. A small ragged walled cyst may be present. The gross appearance is very characteristic. Microscopically various cellular forms are seen amid areas of necrosis. The predominant cell is small often spindle shaped with an oval nucleus. Mitotic figures are numerous. Multinucleated giant cells also are seen. All the embryological forms of glial cells are present. Many thin walled blood vessels occur.

*Treatment*—All forms of treatment of this type of tumor have proved futile. A large subtemporal decompression or actual re-

characteristic architecture. Blepharoplastin can be demonstrated within the individual cells.

The oligodendroglioma is a slow growing frequently calcified tumor with a predilection for the frontal lobes near the midline. Microscopically it presents a unique picture of round cells with spherical nuclei and abundant poorly staining cytoplasm.

The spongioblastoma polare is most commonly a tumor of childhood occurring within the brain stem, optic nerves and chiasm. Microscopically it is made up of unipolar and bipolar spongioblasts. The prognosis is hopeless when the tumor is located



Fig. 140—Frontal glioblastoma multiforme showing ventricular distention. The ventricle is characteristically slightly dilated on the side opposite the tumor.

moval of the entire bone flap may give temporary relief. Complete excision of the tumor is impossible. The preferable procedure in these hopeless cases is the performance of so called internal decompression. In this operation a large amount of the tumor is removed and the skull and dura are closed tightly. Death may occur more quickly with the recurrence.

The ependymoma is a benign, often calcified intraventricular tumor with a predilection for the fourth ventricle. It is firmer and whiter than the other gliomas described. Microscopically it consists of ependymal cells definitely grouped in a radiating fashion around small blood vessels. This presents a

in the brain stem. A tumor can be completely excised if it is located in one optic nerve. This of course necessitates excision of the optic nerve involved, usually with the adjacent portion of the chiasm.

The remaining rare tumors of the glioma group, the pteroloma, astroblastoma and neuroepithelioma, are too rare to be discussed here.

#### INTRAVENTRICULAR TUMORS

Intraventricular tumors present a very interesting group of brain lesions. They may occur in any portion of the lateral third or fourth ventricle. Several types have been found. The most common is the ependy-

oma, but fibromas, apparently identical in structure with the dural meningiomas, are not at all uncommon in the lateral ventricles and most frequently develop on the globus of the choroid plexus. Occasionally a tumor made up entirely of choroid plexus tissue is found. Several other types of tumors occasionally occur, perhaps the most interesting of which are the teratomas. One of the latter which was successfully removed from the third ventricle contained hair follicles and small intestine. Intraventricular tumors can be diagnosed only by ventriculography since the symptoms are largely those of simple intracranial pressure. Many

to be removed piecemeal which can be most readily done with the electric loop. At the completion of the operation the ventricle is filled with normal salt or Ringer's solution. No attempt is made to close the incision in the brain.

Tumors of the third ventricle offer more complicated problems. The osteoplastic flap must extend to the midline. An occipitoparietal flap is turned for tumors in the posterior part of the third ventricle and the dura incised making a flap with its base either forward or downward. The large veins, passing between the cortex and the superior longitudinal sinus, are doubly clipped and divided. The upper portion of the occipital pole is then gently dislocated outward exposing the posterior portion of the corpus callosum. This is incised in the midline and the incision carried through the tela choroidea and between the great veins of Galen into the third ventricle. Tumors in the an-



Fig. 147.—Ventricular displacement from cystic ependymoma. The cyst and ventricular system were injected with oxygen independently.

of these tumors are benign and accordingly every effort should be made to remove them completely.

The ordinary parietal osteoplastic flap, extended anteriorly or posteriorly depending on the location of the tumor, is the procedure carried out for a tumor of the lateral ventricle. After exposure of the cortex a nearly vertical incision is made in a relatively avascular area and either anterior or posterior to the Rolandic region. The cortical vessels are dissected with the electric current, ligated with fine silk or caught with silver clips and the incision carried directly into the ventricle. The cut edges of the cortex are covered with sheet cotton. The ventricle is emptied of fluid by continuous suction and the walls of the incision are held apart with lighted retractors or brain spoons. Many ventricular tumors are pedunculated and it is only necessary to cauterize or clip the vessels in the pedicle and divide it to remove the tumor intact. Others have

the anterior part of the third ventricle are approached through a frontal osteoplastic flap. The anterior part of the third ventricle may be opened by dividing the corpus callosum as in the posterior approach or the anterior horn of the lateral ventricle may be exposed by resection of a portion of the frontal lobe. The third ventricle is then entered through the medial inferior wall of the lateral ventricle. At times the greatly thinned-out floor of the lateral ventricle about the obstructed foramen of Monro may be gently wiped away exposing the underlying tumor. Infiltrating lesions in the third ventricle cannot be successfully operated on and even in the relatively benign types the mortality is high, largely because of damage to the walls of the third ventricle and the resulting hyperthermia.

#### LITURARY TUMORS

Three types of tumors of the pituitary gland are recognized. These are the *chromophil*, the *basophil* and the *chromophobe ad-*

*enomas*. Only the eosinophil and chromophobe adenomas are of surgical interest. The basophil tumor, because of its very small size, does not require surgical treatment and is best treated by deep roentgen therapy. The symptomatology of these three types of adenoma is distinctive, and except in a few cases in which a combined adenoma, characterized by hyperplasia of two of these cell types, occurs, the diagnosis can be made on the symptoms and physical findings alone.

The eosinophil adenoma produces gigantism if it develops before puberty. In an adult, it produces acromegaly, characterized by a marked overgrowth of the entire skeleton. This is most pronounced in the skull, hands and feet. Especially is there excessive development of the frontal sinuses, supra-

submucous resection has given excellent results but there seems to be a considerably higher mortality from meningitis and for this reason it has been largely discarded. The frontal lobe is elevated gently exposing the right optic nerve and anterior portion of the sella turcica. The tumor is seen bulging upward between the optic nerves and in front of the chiasm. The latter may be pushed upward and backward and the optic nerves may be pushed laterally and upward. There is generally a thick capsule, and when it is opened a soft slightly granular adenoma is disclosed. This is gently removed with the curette. Bleeding points are desiccated with the electric current, and if there is considerably slow venous oozing, this can be readily controlled by pressing a small muscle graft into the sella turcica. It is not necessary or desirable to remove all of the adenoma. However, the upper part of the capsule must be freed from the optic nerves and excised. Otherwise, the vision may not be materially improved. The only indications for surgical treatment in eosinophil adenomas is the continuation of headaches or visual impairment or both after deep roentgen therapy.

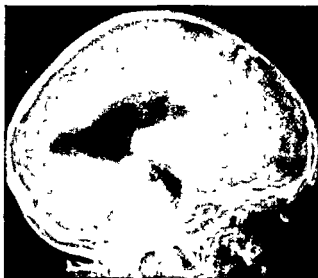


Fig. 148.—Rounded defect in third ventricle from teratoma of third ventricle

orbital ridges and lower jaw. The latter may be so enormously enlarged that the lower teeth project a half inch or more in front of the upper teeth. The hands and feet may become enormous. Severe headaches, usually of the bitemporal variety, are common, but visual disturbances are relatively late and may be entirely absent. Deep roentgen therapy has given excellent results in cases of acromegaly as far as relieving headaches and visual disturbances is concerned, but the skeletal changes rarely regress. Some patients are not influenced by x-rays, and surgical intervention is then indicated.

The frontal operation previously described is the safest method of approach. The intranasal operation in which the floor of the sella turcica is removed, after

The basophilic adenomas are very small frequently not more than 1 or 2 mm. in diameter, and are only found post mortem after careful section. They produce a very interesting group of symptoms now known as the Cushing basophil syndrome. This is characterized by rapid gain in weight, the adiposity being largely confined to the thorax and abdomen, hypertension, marked hirsutism, especially of the face, and the livid, coarse abdominal striae. Roentgenograms show a normal sella turcica, but marked depletion of calcium in the entire skeleton. The visual fields are normal. Deep roentgen therapy is the only treatment indicated.

**Chromophobe Adenoma.**—The chromo-

phobe adenomas constitute by far the largest group requiring surgical intervention. The function of the chromophobe cell is unknown. When the tumor develops before puberty there is usually failure in development of the gonads and of the secondary sexual characteristics more or less marked obesity and in the extreme case the typical Frohlich syndrome of hypopituitarism called dystrophia adiposogenitalis. As a rule the chromophobe adenomas in children do not produce visual disturbances until the child is past puberty. When such changes are found in children a probable diagnosis of either pituitary adamantinoma or suprasellar cyst of Rathke's pouch origin can be made.

**Symptoms**—The symptoms of chromophobe adenoma in the adult are those of hypopituitarism. The earliest symptom is usually loss of libido in the male and diminution or cessation of menstruation in the female. As a rule all sexual functions are lost before the patient comes to the surgeon. The body hairs become scant and in men shaving is only necessary at long intervals or perhaps not at all. Headaches and visual disturbances may not appear for years after the sexual functions are lost. Very rarely some sexual ability and menstruation are maintained. There is usually more or less obesity and many patients have a subnormal basal metabolic rate. Headaches may appear at any time. At first these are bitemporal but after the tumor has penetrated the capsule and extended out of the sella turcica the headaches are more general. They may be exceedingly severe. The typical visual finding is usually considered a bitemporal hemianopsia but this occurs in only 50 per cent of cases. 25 per cent of the patients have either a right or a left homonymous hemianopsia and 25 per cent are so blind at the time of the first examination that the type of hemianopsia formerly present cannot be determined. Bitemporal hemianopsia results from stretching of the cross fibers in the chiasm. Homonymous hemianopsia may be due to pressure on one of the optic tracts posterior to the chiasm but is more commonly due to a notching of one of these tracts by the anterior communicating artery against which structure the tract has been firmly pressed by the underlying tumor. At times a deep groove may be cut across the optic tract and

even the chiasm by this firmly fixed artery. Other visual disturbances may arise from irregularities in the tumor which cause unequal pressure on various parts of the optic nerves or tracts. Marked impairment of vision may occur in one eye even total blindness with very little loss of vision in the other. This is generally the result of a sharp upward bending of the optic nerve at the optic foramen the superior rim of which may cut a deep groove. In the case of large tumors both optic nerve and the chiasm may be so stretched as to appear like thin white ribbons. Visual fields should be made with a small test object preferably not more than 1 or 2 mm in diameter. With such a test object very slight defects in the visual field may be detected and an early diagnosis made before the vision has been irreparably lost. The earliest finding is either a slight notching in the temporal field or a temporal slant. This latter term denotes a slanting defect usually occurring in the upper outer quadrant of the temporal field.

The treatment of a chromophobe adenoma is predominantly surgical. Deep roentgen therapy has been advocated by some workers but has been discarded in the majority of neurosurgical clinics. Practically all patients who have received that form of treatment eventually come to operation even those who had shown temporary improvement in vision. The primary object of the operation is to conserve the vision that is still present. If total loss of optic function has developed much of the visual loss may be restored. The operation consists of turning an osteoplastic flap in the frontal region and approaching the sella turcica either intracranially or extracranially. The writer prefers the latter. The extracranial approach consists of elevating the dura backward to the sphenoidal table where a long incision in the dura is made extending to the midline and the remainder of the operation is then carried out intracranially. The intracranial route consists in elevating the frontal lobe from its anterolateral aspect, carefully protecting the brain with sheet cotton as progress is made toward the sella turcica. Elevation of the brain is facilitated by tapping the lateral ventricle allowing escape of cerebrospinal fluid. The anterolateral approach is preferable to a direct anterior one. The right optic nerve is first exposed and then slight elevation medially will expose the left nerve protruding upward between the two will be seen the pituitary tumor. Occasionally the optic nerves are very short and the tumor presses upward back of the chiasm between the optic tracts. Some tumors grow irregularly upward and may appear more on one side of the midline. Occasionally they extend far out in the middle fossa and the capsule can be best incised lateral to the optic nerve. As a general rule the capsule is opened between the optic nerves. The vessels on the surface of the capsule are dissected and that portion of the capsule lying between

the optic nerves is excised. This makes subsequent procedures easier than through a simple incision.

The adenoma is generally soft and slightly yellowish, and there is frequently cyst formation. If the latter is diagnosed before the capsule is opened the cyst is aspirated. The contents are generally brownish or bile-stained frequently syrupy, and generally contain some yellowish crystals. A bluish capsule suggests a pituitary cyst. The more solid portions of the adenoma are removed with the curette or biting forceps. Complete eradication of the tumor should not be attempted. The upper portion of the capsule at least that part more or less adherent to the optic nerves and chiasm must be removed, and it is generally preferable to remove considerable of the lateral and posterior walls as well. Great care must be exercised in separating the lateral walls from the internal carotid arteries. The optic nerves and chiasm should drop down into normal position when the capsule is removed. At times the operation can be facilitated by dividing the anterior communicating artery. Continuous suction is of inestimable value in maintaining a dry field. Small vessels within the sella turcica may be caught with silver clips or desiccated with the electric current. A small muscle pack is useful in preventing slight oozing from the remaining pituitary tissue lying on the floor of the sella turcica.

Improvement in vision often appears rapidly. At times progress may be noted the first day. The degree of visual restoration depends largely on the duration of the visual loss. Marked optic atrophy is an indication of poor prognosis.

**Pituitary adamantinomas** occur almost entirely in children, but may be found at any age. The symptoms are those of hypopituitarism and differ in no way from those of the chromophobe adenomas. The diagnosis of an adamantinoma can generally be made from roentgenograms. These show deposits of calcium within the greatly enlarged sella and frequently calcium plaques extending well up into the brain. Calcification in other types of pituitary tumor is decidedly rare. The surgical procedure is identical with that for the chromophobe adenoma, with the exception that a serious attempt should be made to remove all of the tumor.

The **suprasellar cysts** which originate in Rathke's pouch present a rather common surgical problem in children. The symptomatology varies greatly. Some patients are unusually thin, suggesting the Lorain type of pituitary dystrophy, some are normal in physical development, and others are obese, with failure in development of the genitalia and secondary sexual characteristics. The cystic tumor may develop anywhere along the pituitary stalk. When the tumor arises at the upper end of the infundibulum, the

symptoms are largely those of increased intracranial pressure. The x-ray plate may show the calcified wall of a cyst lying in the region normally occupied by the anterior portion of the third ventricle. However, calcium deposits may not be demonstrable. The skull shows atrophy due to convolitional pressure, and the suture lines may be separated. The sella turcica and posterior clinoid process may be practically normal, but usually show evidence of pressure. Ophthalmic examination shows choking of the optic disks. The symptoms of the suprasellar cysts are predominantly those associated with interference with the circulation of the cerebrospinal fluid. A tumor developing in the lower part of the infundibulum may press directly on the optic tracts and chiasm, producing either bitemporal or homonymous hemianopsia. Depending on whether the tumor develops beneath or above the level of the chiasm, an early sign may consist of temporal defects in the upper or lower quadrant of the visual field. Primary optic atrophy is commonly found. Occasionally the tumor not only presses on the optic tracts and chiasm, but extends upward, elevating the floor of the third ventricle, and choking of the disks is superimposed on the primary optic atrophy. The sella turcica is generally enlarged and the posterior clinoid process destroyed comparatively early. The most characteristic roentgen finding is a crescentic calcified shadow, generally in the upper part of the wall of the cyst.

These suprasellar cysts may reach an enormous size, some have been found extending upward through the cerebrum nearly to the cortex and laterally to the surface of the posterior portion of the frontal lobe. Tumors of this size, while arising in the midline, are predominantly unilateral. The extent of such a cyst can usually be judged by the flecks of calcium shown in the x-ray plate; but if an exact determination is considered important, a small trephine opening can be made in the skull and a ventricular needle inserted into the cyst. After the contents have been aspirated, air or oxygen is injected and a roentgenogram made.

The surgical treatment for cysts of Rathke's pouch many of which contain adamantinomatous elements, varies with their location and size. The smaller cysts especially those within or just above the sella are ap-



practiced as in the ordinary operation for a pituitary adenoma. Whenever possible all the cyst should be removed and occasionally it is even possible to remove the cyst intact. A large cyst is best approached by resection of the anterior portion of the frontal lobe, its section being carried backward until the complete cyst is well exposed. Even enormous cysts may be successfully removed by this procedure. The prognosis for life and vision is good, provided the optic atrophy has not progressed to a serious extent and the floor of the third ventricle is not damaged during extirpation of the tumor. It is trauma to the walls of the third ventricle which produces the excessive hyperthermia feared by all surgeons when operating in this region.

MAN M. PEET

## INJURIES OF THE SPINAL CORD

In spinal injuries it is not the dislocation, fracture or crush of one or more vertebrae that determines the severity of the symptoms. A very extensive vertebral injury can occur and if the spinal cord itself is not involved complete recovery follows. But frequently a crush of the cord accompanies apparently slight evidence of vertebral trauma. Severe and crippling loss of the motor and sensory function (even death) always results with little hope for useful recovery.

Injury to the spinal cord may result from direct external violence, as from knife or gunshot wounds, or the impact of heavy objects with dislocation or fracture of the spine, laminae, transverse processes or the body of one or more vertebrae. Concussion, compression, contusion or crushing of the cord substance or nerve roots with or without tearing of the meninges can occur. Any or all of these injuries to the vertebral column together with precisely similar effects on the spinal cord and meninges can result from indirect violence causing hyperextension or hyperflexion of the vertebral column.

**Pathology.**—Following vertebral injury a hemorrhage may be produced without or within the dura (hemorrhachis). Epidural hemorrhage comes from rupture of the veins in this region. The epidural fat and areolar tissue fill the epidural space so loosely that the hemorrhage can spread for several segments above and below the point of origin. Intradural subarachnoid bleeding results from the tearing of a vessel in the subarachnoid space about the cord. Many fine vessels float in the subarachnoid space accompan-

ing the spinal nerves or run to the dura lying posterior to the cord, especially in the cervical region. Or the meninges may be torn at the time of injury, and blood may enter the subarachnoid space from the epidural spaces. Provided the cord is uninjured blood in the epidural or subarachnoid spaces does little harm. Occasionally adhesions may form about a clot which may later be a factor in the production of a circumscribed serous meningitis causing local cord compression. Lower motor neuron symptoms, pain and flaccid paralysis have been attributed to hemorrhachis, but these complications must be due to an accompanying nerve injury. Following cranial trauma free blood in great quantities is often removed by spinal tap from the lumbar subarachnoid space. No evidence of anterior or posterior root irritation is produced by this sipping of blood downward from the intracranial cavity. It is highly improbable therefore that hemorrhachis alone in the absence of injury to the cord or roots produces symptoms.

**Hematomyelia.**—Damage to the cord itself results in varying degrees of contusion or laceration, often sufficiently severe to cause complete section. As either one of these conditions results in hemorrhage into the cord, the amount of hemorrhage being in direct proportion to the severity of the trauma, it seems justifiable to group all cord injuries under the common heading of hematomyelia. The work of Allen<sup>3</sup> and McVeigh<sup>4</sup> has shown that hemorrhage and edema with destruction of fiber tracts are the outstanding results of any type of injury, either direct or indirect, to the spinal cord. The student is referred to McVeigh's<sup>4</sup> work for a detailed account of the pathology in cord injuries.

**Concussion of the Spinal Cord.**—In concussion of the brain evidence is slowly accumulating to suggest that in spite of complete subsequent recovery there must be minute lesions to account for the sudden loss of consciousness. The occasional persistence of mild or severe headache following even slight concussion with only momentary unconsciousness confirms this opinion. Concussion of the spine falls into the same category. Following sudden severe jarring injuries there may be definite but fleeting evidence of a cord injury. Complete recovery suggests that what-

ever the lesion in the cord, it was of such a trivial nature that the term "concussion" of the cord seems justifiable.

**Stages of Spinal Injury.**—The progress of a spinal injury may be divided into three stages. (1) the stage of spinal shock; (2) the stage of reflex hyperexcitability, and (3) the terminal stage of diminished reflex ex-

may be noted, with a slight contraction of the inner hamstring muscles on scratching the sole of the foot. The reflexes slowly return. Within three or four weeks the stage of spinal shock gradually changes into that of reflex hyperexcitability. The reflexes become hyperactive. Stimulation of the sole of the foot produces a "mass reflex," with up-

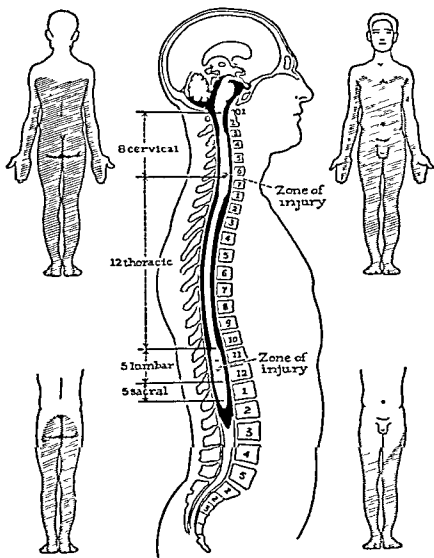


Fig. 149—The relation of the spinal segments to the vertebral column \*

citability, bladder infection, decubitus, etc. In the first stage complete loss of all motor, sensory and reflex action together with control of the sphincters is noted. The paralyzed limbs are flaccid. The extremities lie flat, partially rotated outward in semiflexion. Intestinal, bladder or rectal distention is not felt. In about ten days or two weeks these signs begin to disappear. A Babinski sign

ward movement of the great toes and a rapid contraction of the whole lower limb. Contraction in flexion occurs at the thigh and knee with extension of the ankle. The reflex expulsion of urine and feces may occur. Trophic changes in the skin with formation of decubiti take place. The third stage

\*Homans J.: *Textbook of Surgery*, Charles C. Thomas, publisher

is simply a continuation of the second with a slow increase in the toxicity from cystitis and ascending infection of the kidneys the spread of bed sores and wasting and atrophy of the paralyzed muscles until death occurs.

**Symptomatology of Spinal Cord Lesions.**—Determination of the degree and extent of the injury to the spinal cord is based on the neurological findings. No matter what may have been the type of the injury regardless of evidence from local or roentgenologic examination of dislocation or fracture of the vertebral column if there is no demonstrable motor or sensory loss the spinal cord has not been damaged. The determination of injury to the spinal cord is easy and estimation of the level at which the cord has been injured is also easy but it is extremely difficult to be certain from the neurological findings whether complete and permanent destruction of fiber tracts has resulted or whether loss of function is due to local edema and pressure from which partial recovery at least may be expected.

Injury to the spinal cord exclusive of stab or gunshot wounds results from the impact of the indriven adjacent vertebra. Dislocation with immediate reduction can occur in the cervical region. Here particularly where extreme hyperflexion can occur it seems possible that overstretching of the cord without actual injury from displaced bone may result in a severe lesion. In the shift of position of the bones the cord is pinched and released. No roentgenographic evidence of displacement of bone is demonstrable but indications of a partial or complete cord lesion are all too obvious or the films may show dislocation or fracture with clear evidence of a narrowing of the bony canal and pressure on the cord. Whatever may be the manner in which the cord is injured there are always the two factors to be considered the complete destruction of fiber tracts and the physiologic block of other tracts from pressure consequent on edema and hemorrhage. A bullet or stab wound may cut the cord completely. Fracture or dislocation of the vertebra results in a crushing of more or less severity. Actual transection from the outside is rare. It is a good working rule that if after injury complete motor and sensory loss is present the cord has been hopelessly crushed. But if some degree of sensation and move-

ment remains part of the loss of function may be due to hemorrhage and edema in the cord substance. When this edema subsides and the hemorrhage is absorbed considerable return of function may occur.

**Treatment of Cord Injury.**—Following injury these patients are all in shock and any immediate treatment must be directed to its relief. Great care must be taken in handling or transport lest the injury to the bone be increased with further cord damage. The patient should be carried prone on a stiff well padded litter. If a stretcher is used boards should be placed across the handles for the usual canvas trough permits too much sagging. Pain from pressure on nerve roots may be relieved by opiates although it must be remembered that in cervical cord injuries respiration may be already impaired by phrenic involvement hence morphine must be used cautiously.

While the history of the accident is important in furnishing an idea of the severity of the injury whether hyperflexion or hyperextension has occurred and to what degree or whether or not there are accompanying injuries that might account for any of the symptoms of still greater importance is an attempt to discover what power the patient had in his limbs when he first attempted to move them and how much subjective loss of sensation seemed present. Usually there will be no difference in the patient's condition immediately after injury and at the time the first clinical examination is made. But there will be an occasional case in which evidence of progressive loss or improvement in neurological signs can be demonstrated soon after injury. This fact is of such value in determining the subsequent treatment that every effort should be made to glean this information.

When the patient reaches the hospital he should be placed on a well inflated air mattress or if this is not available on a stiff hair mattress supported by boards across the bed frame and not by a sagging spring. A soft pillow beneath the lumbar curve of the spine will increase the patient's comfort. Regarding any external evidence of injury to the vertebral column either dislocation or fracture as bruises muscle spasm local pain and tenderness hypoaesthesia absence of normally palpable pulsations processes or alteration in

the vertebral curves or position of the head attention should be directed to determining the extent of sensory and motor loss.

Since sensory loss to touch pain and temperature will give more exact evidence of the level and extent of the injury to the cord than motor involvement this examination should be carefully and methodically undertaken. In complete lesions there will be an abrupt and segmental line of anesthesia to all forms of sensation. Very frequently just above the point at which sensation is lost a band of hyperesthesia will be noted. Often a level of increased vasomotor activity as shown by slight flushing or blanching of the skin or marked dermatographism will be observed in the dermatomes supplied by the spinal nerves running from the injured cord segments. Priapism will often be seen and increased sweating will frequently be noted its distribution depending on the level of the lesion. Sympathetic fibers arising from the second thoracic to the second lumbar segments innervate the sweat glands. If the lesion lies above the second thoracic segment profuse sweating may occur in all parts of the body. But if the cord is injured below this level the perspiring area may lie below the level of the sensory loss.

In describing sensory or motor loss following cord injury the level of anesthesia and paralysis in various muscle groups resulting from injury at the different cord segments is best outlined from below upward. The lower the trauma in the cord the less is the sensory and motor loss. Hence it is less confusing first to describe the result of a sacral lesion for any anesthesia or paralysis accompanying a low complete lesion will also be present in a similar injury at a higher level.

A lesion in the lower sacral segments results in a narrow strip of anesthesia on the back of the calf and thigh merging above into an area of perianal and scrotal anesthesia. Flexion but not extension of the foot and toes is lost and sphincter control is much impaired. If the fifth lumbar segment is spared when the upper sacral segments are damaged sensation is abolished over the dorsum of the toes and the plantar surface of the foot plus a narrow strip up the back of the legs and thighs and the perianal region. Flexion and extension of the feet and

toes is impossible and control of both sphincters is lost. Injury at the fifth lumbar level results in impaired movement at the knee with paralysis of the toes ankles and sphincters. The knee jerk is unimpaired the ankle jerk lost. The sensory loss will involve the outer side of the leg from the knee downward the whole of the foot and the perianal and scrotal regions. Following trauma at the fourth lumbar segment sensation will be absent below the knees and loss of power in flexion and extension of the thighs together with impairment of the knee jerks will be added to the neurological findings already described. In lesions below the third lumbar segment not only may the lower end of the cord be involved but since so many pairs of nerve roots from higher segments pass down across this area they may become implicated thus producing a motor and sensory loss suggesting a lesion above its actual position. Furthermore since below this region both roots and cord may be injured asymmetrical and partial lesions are frequently encountered. Injury to the cord at the second and third lumbar segments produces a sensory level corresponding roughly to the middle of the thigh. Knee and ankle jerks are lost but the cremasteric reflex is retained. Complete flaccid paralysis is noted in the legs and sphincters. Lesions in the thoracic area are best localized by the sensory level. In all descriptions of lesions to be outlined next complete paralysis of the legs and sphincters must be considered as included. The sensory loss accompanying lesions at the twelfth thoracic segment corresponds roughly to Poupart's ligament at the tenth thoracic to a line through the level of the umbilicus at the sixth thoracic to the level of the ensiform cartilage at the third thoracic to the line of the nipples and at the first and second thoracic to the line of the clavicles and the inner side of the upper arms as well.

In the motor sphere complete loss of contraction of the abdominal muscles together with abolition of the abdominal reflex indicates a lesion above the eighth thoracic segment. The upper extremities are not involved until the injury reaches the first thoracic segment. With a lesion of the seventh cervical segment the patient lies with his forearms flexed and crossed on his chest. The biceps

reflex may be preserved but the triceps jerk is lost together with contraction of the triceps. The forearm can be flexed but not extended. Slight movement of the wrist and fingers may be present. Sensation is preserved on the outer side of the forearm and hand. In a lesion of the eighth cervical and first thoracic segments contraction of the pupils and narrowing of the palpebral fissure with enophthalmos are produced by sympathetic involvement. If the sixth cervical segment is injured the upper arm can be abducted and externally rotated and the forearm flexed and pronated; is partial motor power is retained in the shoulder girdle. The biceps reflex will be impaired or lost. No movement in the wrist or fingers will be possible. Sensation may be preserved in the outer side of the upper arm. With a lesion of the fourth cervical segment or above motion in both arms will be completely lost. The diaphragm will be paralyzed with consequent danger of pneumonia due to phrenic involvement. Sensation is absent below the base of the neck.

In all these lesions at various levels it has been presumed that the destruction of the cord has been complete. While this is unfortunately only too often the case in many instances the lesion is not complete and hence variations in motor and sensory findings can occur. Since from the standpoint of prognosis and treatment differentiation of a partial from a complete lesion is of extreme importance a review of the clinical findings in either instance seems indicated. In a full transverse lesion of the cord paralysis of the flaccid type is complete in all muscles innervated by segments below the level of the lesion. Reflexes are completely abolished below the level. Sphincter control of the bladder and rectum is gone. Complete retention is noted and later urine and feces pass without the knowledge or volition of the patient. There is an entire loss of all forms of sensation sharply confined to the level of the involved segments and usually capped by a band of hyperaesthesia. The clinical picture is stationary.

However when the lesion of the cord is not complete the paralysis of muscles below the injured segment may not be absolute and the paralysis is rather of the spastic than the flaccid type. The reflexes below the level

of the lesion may be present or even increased. A Babinski sign or clonus may be obtained. Partial control of sphincteric action may remain, and the patient may appreciate that his bladder or rectum is overdistended and when evacuation occurs. Sensory loss is not complete and may not correspond to the level of the injured segment. Strong stimuli and changes in position of the paralyzed limbs may be felt. Lastly the clinical evidence may change rapidly or slowly with a return of power in the muscle groups and diminution in the area of anesthesia.

After a careful neurological examination and detailed recording of the findings roentgenographic studies of the area of the vertebral column involved must be made. Great care must be taken in moving the patient lest cord damage be increased. Every effort should be directed in this examination toward a determination of the amount of impingement of the bone on the neural canal and hence possible direct pressure on the cord. Anterolateral and anteroposterior films are always indicated. Based on the roentgen findings it is often possible to reach a conclusion as to the probable degree of injury to the cord. It will be at once obvious in many instances that the cause of a complete lesion has been the crushing of the cord by the vertebral dislocation. A finding of this character will have an important bearing on subsequent treatment. Frequently roentgen studies will show that the vertebral injury involves a somewhat lower segment of the cord than the level indicated by the neurological findings. This apparent discrepancy may be explained by the fact that at the time of cord injury pulped cord has been driven upward along the fiber tracts within the spinal sheath and has destroyed higher areas or hemorrhage may have spread upward within the cord substance. Furthermore in the lumbar region where the nerve roots run from above downward their involvement at a lower level may suggest that the higher segment from which they originate has been damaged.

A lumbar puncture should always be made to determine first the presence or absence of blood in the spinal fluid and secondly and more important the presence or absence of a block in the spinal fluid circulation at the level of the lesion following

compression of the jugular veins (Queckenstedt test) If the spinal fluid is clear the lesion is not due to an effusion of blood into the subarachnoid spaces (hemitorachis) If no evidence of a block is present it is obvious that there is no impingement of the overlying bone on the lumen of the neural canal nor is the cord swollen from edema or hemorrhage consequent to trauma But if signs of a block can be found then either the fractured or dislocated vertebrae are compressing the cord or edema and hemorrhage consequent on the injury have caused a local swelling of the cord Or a combination of both bony compression and local swelling may cause the obstruction A study of the roentgen films should furnish evidence of the degree of vertebral impingement on the neural canal If there is no dislocation or fracture the block is due entirely to local post traumatic hemorrhage and edema in the cord

Based on the results of these examinations an attempt may be made to decide whether or not the cord has been completely or incompletely injured and whether the symptoms are due to pressure from the overlying bone or to edema and hemorrhage into the cord resulting from the trauma or both

The purpose of all treatment in cord injury is to obtain the maximum return of function in the groups of paralyzed muscles lying below the lesion The injury of the cord may be due to continued pressure from adjacent bone to hemorrhage into and pulp ing of the cord at the point of impact to edema of the cord from the bruise or to a combination of all three of these factors Pressure against the cord from a dislocated or fragmented vertebra can frequently be shown by roentgenographic studies The time element is very important in deciding on the type of treatment Unless the existing pressure on the cord is relieved within eighteen hours the damage will be permanent Therefore unless the patient is seen within that period little or nothing need be done as far as relief of pressure is concerned

What are the methods by which pressure may be relieved? Two methods are available closed reduction of the fracture or dislocation or laminectomy over the level of the lesion The neurological examination will reveal a complete or partial lesion with

stationary increasing or diminishing symptoms The roentgen ray studies may show whether or not the neural canal has been narrowed by the impingement of the surrounding bone Lumbar puncture and the Queckenstedt test will prove whether a complete partial or no block exists

It is the author's belief that no complete cord lesion should be operated on regardless of whether the roentgen ray studies show a narrowing of the neural canal or whether a complete block can be shown by the Queckenstedt test In these cases laminectomy is a waste of time and causes the patient suffering from a useless operation Laminectomy is indicated only when the neurological signs are progressive block or no block and whether or not there is roentgenographic evidence of bone pressure It is true that the author has operated in cases in which there was pressure from damaged vertebrae and has found an edematous swollen cord has removed the bone opened the dura and relieved the tension A certain amount of recovery resulted But one is not convinced that an equal amount of recovery might not have occurred without operation In many cases if the cord has not been entirely crushed even though evidence of a complete lesion may be present at the first examination a surprising amount of function is recovered spontaneously Great pressure may be brought to bear on the surgeon He may feel that if the lesion is complete and if the Queckenstedt test is positive a decompressive laminectomy may give the patient a slight chance for a little increased improvement in function Such is not the fact

The author has operated on seven patients with cervical injury and has seen eight operated on by others without recovery The one patient with a cord injury in this region who recovered to the author's knowledge did so without operation

The opinions here expressed as to the treatment of acute spinal injuries are not universally held Mixer<sup>6</sup> states that patients showing increasing neurological signs or stationary neurological signs plus complete block demand immediate laminectomy if seen within twenty four or forty eight hours of injury Mock<sup>7</sup> Naffziger<sup>8</sup> Coleman<sup>9</sup> Semmes<sup>10</sup> and Gurdjian<sup>11</sup> all subscribe to this opinion Elsberg<sup>12</sup> adds severe root pains

from pressure of dislocated bones on one or more sensory roots as an indication for operation.

If following injury to the vertebral body with involvement of the cord roentgen ray studies show fracture or dislocation manipulative reduction of the deformity by hyperextension is indicated. (See section on *Fracture of the Spine*.)

Cervical fracture and dislocation with cord injury is always serious.

With regard to the late treatment of spinal injuries and by late is meant from two weeks onward after the initial trauma there seems to be general agreement. Operation is indicated if there are increasing clinical signs of cord damage. If the condition is stationary regardless of whether or not a block exists no improvement is to be expected from surgical measures. Manipulative reduction should be attempted in these cases as well unless the interval of time has been too great.

**After Care of Spinal Injury.**—The decision for or against operation and the performance of a decompressive laminectomy or closed reduction in a spinal cord injury is only the opening gun of a long struggle. Vesical retention must be relieved, the development of trophic changes in the skin with the formation of bedsores must be prevented and contractures in paralyzed muscles must be combated.

The proper handling of urinary retention is a much discussed problem. Mixer<sup>6</sup> weighs against the use of the catheter. He and Cahill<sup>14</sup> suggest suprapubic pressure on the fundus of the bladder in an attempt to cause relaxation of the sphincter and the escape of urine. This deep pressure should be made every second hour expressing about 2 ounces at first and increasing the amount up to 6 or 8 ounces at the end of ten days. If this fails then Mixer introduces a large de Pezzer catheter into the bladder through a suprapubic stab wound. With Gurdjian<sup>15</sup> the writer has found that an in lying catheter released every six hours to prevent overdistention and changed every three days gives the best results. Repeated catheterization leads more surely to infection than an in lying catheter. Bladder irrigations with mild solutions are indicated after each catheterization.

Bed-sores following spinal cord injury are very difficult to prevent. Elimination of pressure points by the use of an air or water bed is essential. The heels should be protected by gauze rings. Frequent turning if this is safe will help prevent the breakdown of the skin over the buttocks and trochanter. The skin must be kept absolutely dry. Alcohol rubs followed by stearate of zinc powder should be given every four hours to the back. One of the great objections to suprapubic drainage or manual expression of urine for vesical retention is that with these methods of handling the bladder condition it is difficult to keep the buttocks dry. If and when bedsores appear every effort should be made to prevent infection although this is impossible. If sloughs occur they should be allowed to separate and should not be cut away. Deep collections of pus should of course be evacuated.

Muscle contractures, toe drop or flexion at the knee are best combated by the use of light splints. If a cast is applied every precaution must be taken to prevent a pressure sore.

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## TREATMENT OF MENINGITIS

No more dramatic step in the conquest of a dreaded complication of sinus infection, cranial trauma or operative procedures in the brain has been taken than that resulting from the discovery that the sulfonamide derivatives had a specific action against the common organisms producing meningitis. The treatment of meningitis has been radically changed by the introduction of these drugs. Surgical measures which were at best desperate makeshifts have been forced into the background. They should be used only as aids to sulfonamide therapy to clean up a feeding focus of infection to relieve pressure or to unblock cerebrospinal fluid circulation obstructed by the adhesions consequent upon meningitis. Certain organisms are not definitely affected by these compounds and in such cases laminectomy and drainage may be necessary adjuncts to these drugs. But the treatment of meningitis due to streptococci, pneumococci, staphylococci or meningococci infection consists in prompt diagnosis by lumbar puncture, smear and culture and the immediate administration of the proper sulfonamide preparation in full dosage. If possible the patient's condition permitting it as soon as the proper blood level of the drug is reached the original source of infection—maxillary or paranasal sinus, compound fracture or septic focus elsewhere—should be drained and sterilized at the earliest opportunity to prevent reinfection.

The dosage of these drugs by mouth is as follows:

	Initial Dose	Maintenance Dose	Interval Day and Night
Adults—100 lb or over	50-60 grains	15-20 grains	Every 4 hours
Adults—50 to 90 lb	30-50 grains	10-15 grains	Every 4 hours
Children	20-30 grains	5-10 grains	Every 4 hours
Babies	10-20 grains	5 grains	Every 4 hours

The maintenance dose should be continued until the temperature has been normal for seven days. The higher dosages are recommended for sulfanilamide by mouth in handling streptococci and meningococci meningitis; the smaller amounts for sulfapyridine orally in staphylococci meningitis and for sulfathiazole orally in pneumococci meningitis.

If the patient is too sick to take the drug by mouth or nasal tube intravenous therapy is indicated. For staphylococci meningitis sodium sulfapyridine should be given in an initial dose of 0.06 gm per kilogram of body weight made up in a 5 per cent solution in sterile freshly distilled water. It is important to give

this solution slowly and carefully by vein avoiding the passage of the material into the surrounding tissue where it may cause a slough. Never add the sodium sulfapyridine solution to other material given intravenously such as blood, glucose or normal saline solution. Subsequent doses should be calculated on the basis of 0.03 gm per kilogram of body weight and given intravenously every six hours. As soon as the patient's condition warrants it, sulfapyridine should be given by mouth.

In the treatment of streptococci meningitis the patient may be given sulfanilamide intravenously if he is too sick for adequate oral administration. Add 80 gm of sulfanilamide crystals to a liter of freshly prepared normal saline solution which has been brought to a boil. One hundred cubic centimeters of this solution contains 120 grains of sulfanilamide. This solution may be given under the skin. The initial dose is 90 grains for an adult followed by a maintenance dose of 90 grains every four hours day and night. (Follow the tables on oral administration.)

Pneumococci meningitis may be treated by intravenous therapy with a 5 per cent solution of sodium sulfathiazole in sterile distilled water in an initial dose calculated at 0.06 gm per kilogram of body weight. Subsequent doses intravenously every six hours should be given calculated at 0.03 gm per kilogram of body weight. Homologous type antipneumococcus serum intravenously is recommended in pneumococci meningitis in late cases or if response to chemotherapy is not prompt and adequate. If the patient is not hypertensive to serum an initial dose of 500,000 units is advisable with a supporting dose of 100,000 units every eight hours.

During the use of any of these drugs a record of urinary output should be kept and the excretion should never be permitted to fall below 1000 cc in twenty-four hours. If this rule is strictly observed complications referable to the urinary tract from the use of these drugs will be avoided. Fluid should always be forced up to at least 3500 cc per day especially when sulfathiazole is being administered and the output of urine should be kept at 1000 cc daily as a minimum. None of these drugs should be administered by lumbar puncture or ventricular tap. Repeated lumbar taps or continuous lumbar drainage is not advisable.

As therapy. Spinal puncture may be done when indicated to determine the bacterial and cellular content of the spinal fluid. In treating all forms of meningitis it is advisable to have the blood level of the drug reach 15 mg per hundred cubic centimeters as soon as possible and to maintain it at or near that level until clinical improvement is clearly obvious. Since the blood level drops rapidly it is important to maintain the level by repeated doses every four hours orally or every six hours intravenously day and night.

The drug treatment of pneumococci or staphylococci meningitis is greatly aided by the judicious use of surgical measures. Feeding focus should always be elimi-



nated whenever the condition of the patient permits. Since these organisms produce thick pus with adhesions and interference with the circulation of cerebrospinal fluid surgical treatment may be indicated to relieve block or intracranial pressure.

It is to be recommended that when possible laboratory control of bacterial chemotherapy be carried out but inability to do examinations of the blood and urine should never be considered a contraindication to the use of the sulfanilamide compounds. If facilities are available hemoglobin determinations should be made every other day during the first week of treatment and once a week thereafter. Total and differential white blood cell counts should be made every other day for the first seven days and (particularly important) if the patient continues treatment with sulfanilamide or its derivatives every two days between the fourteenth and the fortieth day. The urine should be examined on alternate days if the patient is receiving sulfapyridine or sulfathiazole. The urine should be examined microscopically for blood. The output of urine of patients being treated with sulfathiazole or sulfapyridine for serious infections should be recorded daily. Patients receiving sulfanilamide compounds should be seen at least once a day and should be questioned as to the presence of headache or malaise, as these are frequently important early symptoms of toxic reactions. Patients should be inspected at each visit for the presence of jaundiced scleras (acute hemolytic anemia or hepatitis), pale mucous membranes (acute hemolytic anemia) or rash. The temperature should be recorded. If fever recurs after the patient's temperature has been normal in the course of treatment with sulfanilamide or one of its derivatives the drug should be discontinued immediately or if recently discontinued should not be resumed unless it has been demonstrated that the fever is due to a recurrence of the infection. Whenever therapy with the sulfanilamide drugs is stopped because of a drug reaction fluids should be forced so that 5000 cc per day is taken in order to wash out the drug.

Agranulocytosis is extremely rare before the fourteenth day of therapy. It is imperative that total and differential white cell counts be made for patients still under treatment after the fourteenth day (every two days from the fourteenth to the fortieth day). If the percentage of polymorphonuclear leukocytes falls to 50 per cent or less in an adult patient the drug should be stopped immediately. Granulocytopenia without agranulocytosis may occur.

Any patient who has had a toxic reaction to one of the sulfanilamide group of drugs may have a second and more severe reaction if one of these drugs is prescribed again. To such patients a small test dose of the drug (0.1 to 0.3 gm) should be given and the patient observed twelve hours before a therapeutic dose is started following which he must be carefully observed and the drug immediately stopped on the first appearance of any toxic manifestation.

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#### TUMORS OF THE SPINAL CORD

Because of the clinical importance of their relation to the cord and its covering membranes spinal cord tumors have been divided into three major groups: (1) *intramedullary tumors* arising within the substance of the cord or medulla; (2) *extramedullary tumors arising outside the cord* and (3) *tumors of the cauda equina* arising within the dura and among the nerve roots of the cauda equina. The extramedullary tumors are subdivided into *intradural* and *extradural* according to their relation to the dura (Fig. 150).

**Signs and Symptoms.**—The early signs of spinal cord tumors are determined largely by the position of the neoplasm in relation to the cord and to the emerging nerve roots. A tumor arising from a nerve root may give symptoms referable to the nerve root long before there is any evidence to suggest spinal cord involvement unless this latter possibility is definitely considered in the differential diagnosis. If on the other hand the tumor compresses the spinal cord in its early stages the signs readily suggest the true site of the pathologic process. Accordingly neoplasms of the spinal cord may be considered as presenting two groups of symptoms: (1) those due primarily to compression of the nerve roots and (2) those due to early compression of the long fiber tracts of the spinal cord.

With compression of the long fiber tracts the signs are the obvious ones of disturbed spinal cord function and the attention is at once directed to the cord. The problem is then to determine whether the clinical picture is attributable to a tumor to some intrinsic disease of the cord such as multiple sclerosis or to a systemic disease such as pernicious anemia. The earliest clinical manifestations of which may be referable to spinal cord involvement before evidence of the condition is demonstrable in the blood picture.

When on the other hand the early signs are due to involvement of the nerve roots within the vertebral canal without obvious compression of the cord these are referred to the peripheral distribution of the involved roots. The symptoms may then be confused with symptoms referable to disturbed functions of such organs as the kidney, gallbladder, appendix or prostate and

become sufficiently great, abolition of the sensory impulses

Paresthesias, such as tingling, pins and needles sensation and finally a sense of heaviness or dead feeling, referred usually to the side of the lesion, arise from pressure on the dorsal columns. Pressure on the spinothalamic tracts more commonly causes a sense of burning or of extreme cold and, finally, loss of the pain and temperature sense referred to the opposite side of the body. Thus, a tumor on the left side of the spinal cord causing pressure on the dorsal columns will produce a sensation of pins and needles in the left lower extremity and, if

tension (Babinski), and, in long-standing cases with marked compression of the cord, massive withdrawal reflexes, the extremities being withdrawn involuntarily on the slightest stimulation, such as moving the bed covers or merely touching the skin in testing sensation. At first only a sense of heaviness and slowing of movement without active loss of movement may be noticed, gradually increasing until marked spasticity and loss of voluntary movement occur.

Involvement of the short, but multiple neuron pathway controlling bladder and rectal function is evidenced by disturbances in urination—difficulty in starting the urinary

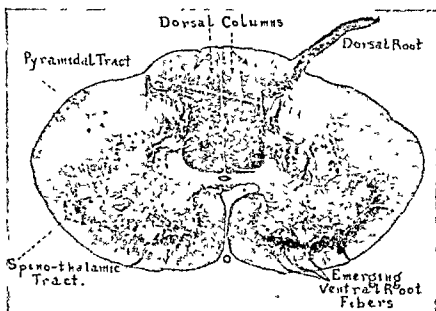


Fig. 151.—Photomicrograph of a transverse section of the cervical cord of a five week old infant, Weigert's method stain.

the tumors is sufficiently ventral to cause pressure on the left spinothalamic tracts, a sense of burning or of icy cold in the right lower extremity.

The long motor pathway, known as the pyramidal system and controlling voluntary movement, is the only clinically important motor system, since signs arising from involvement of this tract overshadow those due to the less prominent motor systems, such as the rubrospinal.

The principal signs referable to compression of the motor pathway are motor weakness, spasticity, increased deep reflexes, diminished abdominal reflexes, altered plantar responses, that is, fanning or dorsal ex-

flow, urgency or, if certain segments of the cord are involved, incontinence. Unless the cord segments directly controlling the bladder and rectum are involved, signs referable to the bladder occur relatively late in the course of extramedullary spinal cord tumors, frequently not until the motor signs are massive and the sensory changes are advanced. In intramedullary tumors and in intrinsic diseases of the cord, such as multiple sclerosis, they appear early.

**Root or Radicular Syndrome.**—Unilateral root involvement may occur in tumors arising directly from the nerve roots within the subarachnoid space, or the root may be compressed secondarily by tumors arising from

the search may lead away from the spinal cord instead of to it, sometimes even to the point of surgical exploration of the suspected area. For this reason, even though few signs of cord involvement are present, symptoms referable to a given organ but failing to fit the clinical picture usually presented by that organ should arouse suspicion of a spinal cord tumor.

For convenience, the signs of extramedullary spinal cord neoplasms may be grouped

sure may be exerted on the roots for many years with only vague signs to suggest the presence of the tumors.

*Long Tract Syndrome.*—So far as the clinical signs of spinal cord tumors are concerned, the function of only the two major long neuron pathways need be considered. These are the sensory and motor paths. While a number of other tracts are recognized and their function is well known, their involvement is, as a rule, overshadowed by

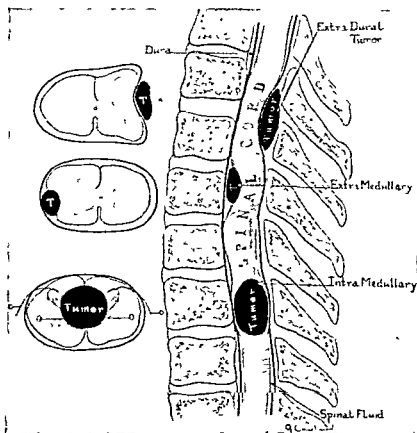


Fig 150—Schematic drawing to show the relation of tumors to the spinal cord and dura

in two syndromes: the long tract syndrome and the root or radicular syndrome, either of which or both may be present. Intra-medullary tumors involve primarily the central gray matter of the cord, and the symptoms from the so-called central gray syndrome. In effect the clinical picture is a combination of the bilateral radicular syndrome and the syndrome of the long tracts. Tumors of the cauda equina are usually large, soft, jelly-like masses surrounding the nerve roots and producing radicular signs. Because of their jelly-like consistency pres-

the more striking signs produced by the major paths.

The important *sensory tracts* are: (1) the dorsal sensory columns of Goll and Burdach, which carry discriminative sensation, such as muscle, joint and tendon sense and vibratory and discriminative tactile sensation from the same side of the body, and (2) the lateral and ventral spinothalamic tracts, which carry pain and temperature from the opposite side of the body (Fig 151). Pressure on these afferent pathways produces first, paresthesias and, finally, when it has

become sufficiently great, abolition of the sensory impulses.

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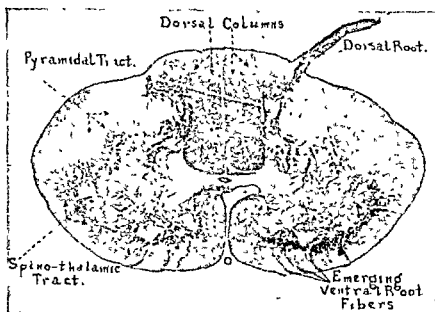


Fig. 131—Photomicrograph of a transverse section of the cervical cord of a five week old infant, Weigert myelin stain

the tumors is sufficiently ventral to cause pressure on the left spinothalamic tracts, a sense of burning or of icy cold in the right lower extremity.

The long motor pathway, known as the pyramidal system and controlling voluntary movement, is the only clinically important motor system, since signs arising from involvement of this tract overshadow those due to the less prominent motor systems, such as the rubrospinal.

The principal signs referable to compression of the motor pathway are motor weakness, spasticity, increased deep reflexes, diminished abdominal reflexes, altered plantar responses, that is, fanning or dorsal ex-

flow, urgency or, if certain segments of the cord are involved, incontinence. Unless the cord segments directly controlling the bladder and rectum are involved, signs referable to the bladder occur relatively late in the course of extramedullary spinal cord tumors, frequently not until the motor signs are massive and the sensory changes are advanced. In intramedullary tumors and in intrinsic diseases of the cord, such as multiple sclerosis, they appear early.

**Root or Radicular Syndrome.**—Unilateral root involvement may occur in tumors arising directly from the nerve roots within the subarachnoid space, or the root may be compressed secondarily by tumors arising from

the meninges at the point of emergence of the nerve root or by tumors lying outside the dura adjacent to the foramen of exit of the nerve as it leaves the vertebral canal.

Pressure on the nerve may give rise to pain referred to its peripheral distribution. Thus involvement of the eighth cervical root may give rise to pain in the hand of the fourth thoracic root to pain in the breast and of the seventh or eighth thoracic root on the right side to pain in the region of the gallbladder.

A tumor on a nerve root may exist for a long time without producing definite sensory changes referable to the root involved or if

spinal cord from within and expand so as to cause pressure on the neural components of the cord at the point at which the neoplasm takes its origin. The more central portion of the spinal cord consists of the gray matter through which the crossing pain and temperature fibers pass and the ventral gray horns from which the motor roots emerge. The signs arising from a tumor in the substance of the spinal cord are due therefore to the segmental involvement of the crossing pain and temperature fibers and of the ventral nerve roots and to compression of the long fiber tracts as well. The clinical picture is a combination of the radicular and long

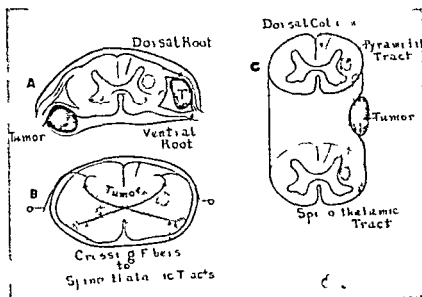


Fig 15—Schematic drawing to show the relation of tumors to the spinal cord and the nerve roots of the long fiber tracts. A Radicular syndrome. B central gray syndrome. C long tract syndrome.

the tumor arises from the ventral motor root before it has joined the sensory root the earliest signs may be atrophy of the muscles supplied by the root fibrillary twitchings and weakness. Frequently however the tumor involves both the sensory and the motor root and both sensory and motor functions are disturbed simultaneously with atrophy appearing in the region in which pain is felt. Thus the symptoms and signs are due at first to the nerve root alone. Later signs of cord compression and involvement of the long pathways are added to the clinical picture (Fig 15<sup>o</sup>).

**Central Gray Syndrome**—Intramedullary tumors in their early stages involve the

fiber tract syndromes partly segmental and partly suprasegmental.

In their earliest stages intramedullary tumors present the syndrome of root involvement since they usually early implicate the ventral gray motor cells and some of the incoming sensory fibers. This involvement however is usually bilateral that is implicating the ventral roots of both sides in contrast to the unilateral involvement in extramedullary tumors. In addition intramedullary tumors early interfere with the crossing pain and temperature fibers as they pass through the central gray matter while other forms of sensation are affected only later. Thus in the early stages of an intra

medullary tumor, one sees disorientation of sensation with bilateral segmental loss of the pain and temperature sense and bilateral motor weakness and atrophy. By dissociation is meant loss of the pain and temperature sense without loss of tactile or discriminative sensibility. The number of body segments in which this loss is found depends on the longitudinal extent of the tumor.

In general it may be said that in intramedullary tumors the sensory loss is greater in the body segments nearest the involved segments of the cord while in extramedullary tumors the greatest loss is in the more peripheral segments that is those farther away from the level of the tumor (compare sensory charts Fig 153).

Owing to involvement of the central gray matter and the fibers that immediately surround it disturbance of the bladder and rectal functions occurs earlier in intramedullary than in extramedullary tumors.

Because of their symptoms intramedullary tumors have frequently been mistaken for chronic poliomyelitis or syringomyelia or some other form of intrinsic disease of the spinal cord.

**Diagnosis**—If the physician's attention is early focussed on the spinal cord as the probable seat of disease the nature of the pathologic process can usually be determined by a combination of the history, the neurological signs and the special tests.

Frequently even the expert is unable to distinguish by neurological signs alone between spinal cord tumors and atypical forms of multiple sclerosis, syringomyelia, atrophy of the cord or combined sclerosis, all of which may give rise to signs of long tract and radicular involvement. In such cases a detailed history in which the exact chronological sequence of signs and symptoms is elicited is essential. Frequently by the history alone the level of the tumor and its relation to the spinal cord can be determined. Thus if the first symptom is pain referred to the right side of the chest in the nipple line, if this is followed by numbness and tingling in the right leg with weakness in the right leg and a sense of extreme cold in the opposite leg, if on getting into his bath the patient does not feel hot water on the left leg as well as on the right and if the history shows a gradual and progressive ex-

clusion of symptoms with evident signs of spinal cord involvement it is fair to assume the presence of an extramedullary tumor involving the right fourth thoracic root compressing the spinal cord laterally on the right side so as to involve the right pyramidal tract, the right dorsal column and the right spinothalamic tract.

Most chronic intrinsic diseases of the spinal cord do not materially increase the size of the cord; in fact some of the chronic degenerative diseases cause it to atrophy. A neoplasm on the other hand either increases the size of the cord or fills the vertebral canal within whose rigid walls it is en-

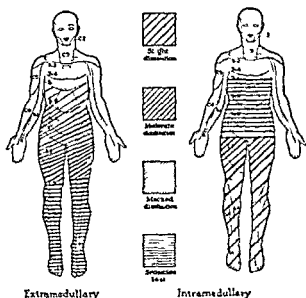


Fig 153—Chart showing typical sensory changes in (1) extramedullary and (2) intramedullary tumors. Note that the greatest sensory loss in intramedullary tumors is in the proximal segments.

closed. Thus spinal cord tumors are expanding lesions which form an obstruction like a dam across the narrow vertebral canal, obliterating the subarachnoid space, preventing the flow of the spinal fluid and compressing the cord whereas the intrinsic diseases cause no obstruction of the subarachnoid space, no block of the spinal fluid and no compression of the cord itself.

Among the lesions producing subarachnoid block are spinal cord tumors, inflammations, both acute and chronic, displacements of the vertebrae or intervertebral disks and hypertrophic arthritis. Among the spinal cord tumors may be listed the following:

<i>Intradural</i>	<i>Extradural-Intradural</i>	<i>Extradural</i>
Glioma	Meningioma	Chondroma
Ependyoma	Perineural fibroma	Sarcoma
Medulloepithelioma	Neurofibroma (von Recklinghausen)	Lymphosarcoma
Hemangioma	Fibrosarcoma	Fibrosarcoma
	Lipoma	Chordoma
	Hemangioma	Osteoma
		Fibroma
		Hemangioma
		Myeloma
		Simple cyst

The evolution of symptoms in such widely divergent pathologic entities must of necessity show great variation. Important determining factors, in addition to the position of

a tumor which is soft and extremely vascular may be subject to intermittent alterations in size dependent on changes in the local blood supply and consequently may

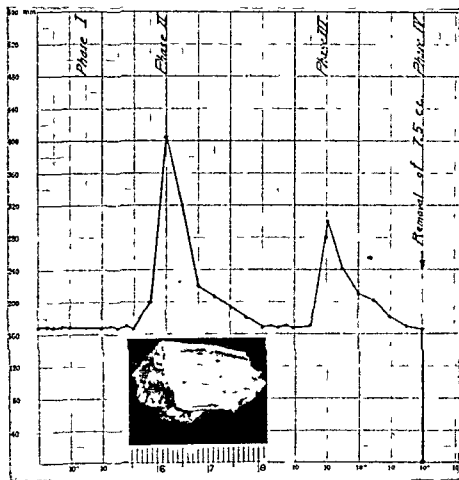


Fig 154—Spinal manometric chart showing a delayed rise in the presence of an extradural meningioma attached to the dura. Part of the tumor was soft and part had formed dense bone. Note the delayed rise shown in the accompanying manometric chart. Unless the manometric readings were carefully made, the total rise might be considered normal, whereas, the delayed rise is definitely indicative of an obstructed subdural space.

the tumor, which has been discussed, are its consistency and rate of growth. It is obvious that compression by a hard tumor will cause greater damage than would be produced by a soft tumor of the same size. Furthermore,

display intermittent variations in its symptomatology. Even in tumors of the same type, such as meningiomas, great variation in consistency may be found. Some are very soft, while others have the hardness of bone.

Obviously the evolution of symptoms in these two instances will be dissimilar even though the tumor in each case is a meningioma.

causes an increase in the subarachnoid spinal fluid pressure as measured by a lumbar puncture needle and a water manometer when the space is obstructed by a tumor or

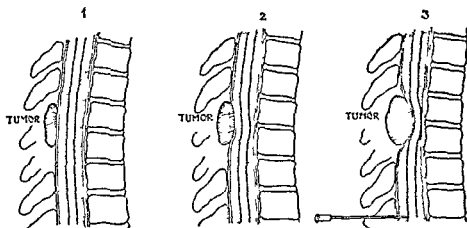


Fig. 155—Schematic drawing showing relation of an extramedullary tumor to the spinal cord after removal of the fluid cyst.

The rate of growth will also determine the progress of the symptoms. Where a structure is confined within rigid walls as is the spinal cord symptoms appear earlier with the more rapid growth of the tumor.

normal rise does not occur. Unfortunately the significance of this phenomenon described many years ago by Queckenstedt was not fully appreciated until relatively recently when it was submitted to intensive



Fig. 156—Enlargement of the cervical vertebrae and the vertebral canal due to the presence of an intracanal lipoma.\*

**Manometric Test**—In making a differential diagnosis between tumors and intrinsic spinal cord diseases special tests such as the manometric study of the spinal fluid are of great value. Compression of the veins of the neck in an unobstructed subarachnoid space

study and a number of important modifications of the test were introduced. The routine manometric study of the spinal fluid has become one of the most important procedures in the study of spinal cord diseases.

\* *Arch. Neurol. & Psychiatry*, vol. 18.



The test however if it is to be of value must be carefully performed and the essential details observed the period of compression being timed and the rise and fall in the manometer noted accurately every five seconds Done in a haphazard manner without due attention to details the procedure is of little value A lumbar puncture should never

to 40 mg of protein per 100 cc and is clear in the presence of a tumor the amount of protein is increased frequently to 100 or 200 mg and in long standing cases to 1000 mg or more so that coagulation of the fluid occurs

*Determination of the Tumor Level—(1) Sensory Level—By careful observation of*



Fig 157



Fig 158



Fig 159

Fig 157—Multiple neurofibromas Showing tumors lying ventral to the nerve roots and on one side extending through the intervertebral foramen forming a dumb-bell tumor (von Recklinghausen)

Fig 158—Tumor of the cauda equina showing the jelly like mass filling the dural sac through which the nerve roots pass

Fig 159—Large meningioma compressing the spinal cord conus and cauda equina

be made in these cases without measuring the spinal fluid pressure with a water manometer

*Examination of Spinal Fluid—*Compression of the spinal cord by tumors causes pressure on the blood vessels diapedesis an increase in the protein content of the spinal fluid and if long standing xanthochromia Normally the spinal fluid contains from 20

the level at which lost or diminished sensation becomes normal the sensory segmental level of a tumor is determined When the tumor involves a nerve root a zone of hyperesthesia may at first be found and this may give way to a zone of loss of sensation below which sensation may be present but diminished If the sensory level is not definite it may be accentuated by deliberate

removal of from 10 to 15 cc of spinal fluid. The cerebrospinal fluid acts as a buffer to support an extramedullary tumor and the latter on removal of the fluid will press directly on the cord making possible the demonstration of a definite sensory level (Fig 155). Any increase in symptoms after removal of spinal fluid is generally a welcomed sign, since it suggests the presence of an extramedullary rather than an intramedullary tumor. Removal of fluid is without effect on intramedullary tumors, since it causes no change in their position. (2) *Motor Level*—Focal atrophy, fibrillary twitchings and focal paralysis are significant evidence of the segments of the cord involved except in such muscles as the intercostal where they are not readily observed.

*X-ray Changes Indicative of the Tumor Level*—Enlargement of the spinal canal by pressure atrophy of the vertebrae may be demonstrable in x-ray plates and may indicate the exact position and extent of the tumor (Fig 156). Not infrequently certain extradural tumors such as osteomas chondromas and some meningiomas, may be seen directly in the roentgenogram.

In a comparatively few instances when neither a sensory nor a motor level can be determined otherwise, iodized poppy seed oil may be injected into the cistern and the level of the obstruction determined roentgenographically.

*Segmental and Vertebral Level*—Since the spinal cord is shorter than the spinal canal the segments of the former do not correspond to the overlying vertebrae except perhaps in the cervical region. In the upper thoracic region each spinal segment lies approximately two vertebrae higher than the corresponding vertebra and in the lower thoracic, three higher.

*Indications for Treatment*—Once the diagnosis of a spinal cord tumor is established, the tumor should be removed. When this cannot be done, as in the case of certain intramedullary tumors a wide decompression is indicated, i. e., removal of the vertebral arches and opening of the dura.

*Types of Operation*—Two types of operation for tumors of the cord are available: (1) bilateral laminectomy, in which the spinous processes and laminae on both sides are removed and (2) hemilaminectomy

(Alfred S. Taylor), in which the spinous processes, interspinous ligament and laminae on one side are left intact the laminae of only one side being removed. This second type of operation is more difficult and requires greater skill than the first, but properly performed is preferable in the cervical and lumbar regions especially if the bones have been eroded by the neoplasm or if the tumor is ventral to the spinal cord. For exploratory purposes in these two regions it is also the best procedure. A hemilaminectomy can be converted with little difficulty into a bilateral laminectomy should conditions demand it.

No more brilliant results can be found in surgery than those following successful removal of a spinal cord tumor and fortunately the majority of these tumors are removable. Symptoms are relieved, the bedridden patient walks again and the paralyzed and helpless resumes, in many cases his former life of activity.

BRON STOOKLEY

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## INJURIES OF THE PERIPHERAL NERVES

**Etiology.**—Injuries of the peripheral nerves may occur as the result of direct injury by gunshot or stab wounds. They may occur in dislocations of joints and in fractures, resulting either from the immediate injury or later from compression of a callus. Injuries are produced by pressure of casts or bandages, prolonged pressure in sleep, anesthesia or wasting disease, compression by new growths, osteoarthritis of the spine, traumatic aneurysms, cervical ribs, prolonged stretching in some occupation or an unusual position during an operation, excessive use of muscles as in long thoracic nerve palsy, and continued mild trauma, as in peroneal palsy in cyclists. Nerves may be injured at birth, by spinal anesthesia, by accidental intraneural injections, in the neuritides produced by toxic substances and infectious disease and by contagious inflammatory processes.

**Pathology.**—When a nerve has been severed or severely injured the distal segment undergoes wallerian degeneration, the neurofibrillae become swollen, fragmented and granular and disappear. The myelin is broken up into masses and globules and vanishes. Soon after injury regenerative changes, with an increase in the amount of granular cytoplasm, occur in both segments but such abortive fibers as are formed in the distal segment degenerate in from three to eight days. In the proximal segment, after an increase in cytoplasm, the nuclei increase and by the fourth to sixth day protoplasmic bands are formed, affording pathways along which the regenerating neurofibrillae from the proximal segment find their way, as well as into empty sheaths in the distal segments. True regeneration occurs only from the proximal segment.

When a nerve has been severed, the ends separate. Immediately the formation of scar tissue begins between the severed ends. When the regenerating axons of the proximal segment reach the end, they are unable to penetrate the connective tissue and are turned back in a twisting spiral coiling mass which goes to form the proximal bulb or true neuroma. The end of the distal segment becomes enlarged into a bulb by for-

mation of connective tissue and forms the distal bulb or false neuroma.

When a nerve is incompletely severed, a lateral notch with a subsequent lateral notch neuroma is formed. A nerve injured only internally may give rise to a fusiform neuroma.

When a nerve is injured by compression by a callus or scar tissue following extensive injury to some adjacent structure, it may be displaced and surrounded by a scar which may be diffuse or band like. The nerve itself, smooth or rough, usually is gray and firm and may contain an increase of connective tissue and new nerve fibers.

**Symptomatology.**—When a peripheral nerve is severed, a motor paralysis, a loss of touch, temperature, pain and deep sensibility in the area supplied by this nerve, a loss of vasomotor supply and so called trophic changes ensue.

When a nerve is but partially injured, the loss of function is incomplete, and if only a part of a nerve is completely severed or severely injured, then only some of the muscles will be paralyzed and a part of its sensory supply will be anesthetic.

The paralysis, affecting the lower motor neuron, is a flaccid one, associated with atrophy and a "reaction of degeneration" to electrical stimulation.

Muscles which produce certain movements may be supplied by more than one nerve. Because of this and other mechanical reasons a movement expected to be impossible because of a particular nerve palsy may be performed by other unaffected muscles, this is known as supplementary motility, an example is extension at the wrist in radial nerve palsy by strong closure of the fingers.

When a nerve is severed there is loss of sensation to touch, temperature and pain in the cutaneous sensory supply of that nerve. Such an area is fairly constant in distribution and extent for each particular nerve. Joint and vibration or deep senses are also lost, but over a much smaller area the reason for which is explained in the next paragraph.

Sometime after severe injury to a particular nerve it will be found that there has been a return of sensation to more severe pin prick and high or low degrees of tem-

perature (protopathic sensation) on the borders of sensory loss. This early return of certain sensations must not be interpreted as a sign of regeneration or of incomplete lesions. It occurs as the result of assumption of function of adjacent uninjured nerves and is known as a sensory overlap. It occurs in areas peculiar to each individual nerve. For example it never occurs in the distal phalanges in lesions of the ulnar or median nerve. Overlap may be so extensive in the radial nerve that the loss of pain to severe pin prick may completely disappear but the loss of tactile sense will always be found.

After the initial trauma pain is rare in complete interruption of a nerve. In partial lesions with the exception of cases in which *causalgia* develops, *paresthesia*, *hyperesthesia* and pain are not as frequent or as severe as one might expect. In the areas where sensation to pain returns as the result of overlap a peculiar sensitivity to stimuli occurs described as a hyperpathic reaction.

In certain partial lesions a severe at times unbearable pain occurs precipitated by contact with dry surfaces jolting even emotional changes at times it is relieved by keeping the skin moist and because of continued moisture the skin is macerated. Under normal conditions it is often glossy and smooth so that such cases have been described as glossy skin and *causalgia*.

As a consequence of an injury to a peripheral nerve the affected muscles atrophy but the amount of atrophy is no indication of the severity of the injury. Marked early and extensive atrophy is typical in lesions of the ulnar nerve that sometimes are not severe.

Flaccidity is characteristic of peripheral nerve lesions. But a short time after injury it is often masked by fibrosis of muscles and fibrosis, ankylosis and capsular shortening of joints.

Many so called trophic vasomotor and secretory changes are seen following peripheral nerve injuries: keratosis, ulcerations, atrophy of the skin and failure of desquamation, increased and diminished sweating, overgrowth and ridging of nails, overgrowth of hair and atrophy of muscle. Ulcerations of the skin initiated by some form of trauma occur in an analgesic area as the distal seg-

ment of the little finger in ulnar nerve lesions or the proximal phalanx of the index finger in a median nerve palsy.

About ten to fourteen days after a nerve is severed or severely injured a change occurs in its irritability to electrical stimuli and likewise in the muscles it supplies. The nerve loses its irritability and the muscle no longer responds to the faradic current. During the state of complete denervation or when the reaction of degeneration is complete the muscle is hyperirritable to galvanic stimuli. When recovery begins the amount of current necessary to produce contraction suddenly increases. During the state of denervation the anodal closing stimulus becomes as effective as the cathodal closing one. The contractions of the muscle are slow and vermicular like and tetanus throughout the flow of current results from stimuli little stronger than those which produce luminal contraction. With progressive currents of long duration over a second during denervation the amperage is very low for all time during regeneration there is a sudden marked rise of amperage for increasing durations. The muscle likewise requires a stimulus of much longer duration whatever its strength so that during denervation the chronaxie is increased. Strength duration curves show a discontinuity during regeneration.

Other causes of inability to move a part or the whole of an extremity must be differentiated from an injury to a nerve for example section of tendons or muscles. Here the muscle proximal to the injury will contract when stimulated by electricity but no movement will be produced in the segments about a joint which it normally moves.

**Diagnosis**—When it is determined that a nerve is injured it is imperative to know whether it is partially or completely interrupted whether by severance or compression. When only some of the muscles supplied by a particular nerve are completely paralyzed and sensation particularly to touch is preserved within the limit of the sensory supply of the nerve and the reaction of degeneration does not develop in the muscle after fourteen days the nerve is only partially injured and operative treatment should be deferred. Whether a nerve is severed or severely compressed all function

may be lost so that at a particular time all the muscles may be completely paralyzed and a complete sensory loss may be present and the reaction of degeneration may have developed. Only if at a later date there is observed a return of some of the functions can one say that the nerve is not severed.

If it has been determined that a nerve has been injured it becomes necessary to discover the particular nerve involved. A comprehensive knowledge of anatomy and physiology is necessary for accurate diagnosis

aspect of the radial side of the hand and thumb and part of the proximal phalanges of the index and middle fingers. Because of the extensive overlap there may be very little or even no loss of pain to severe pin prick.

When the *median nerve* is severed the thumb is held in the plane of the palm producing a simian or ape hand. Because of supplementary motility many movements expected to be impossible may be present. The most characteristic defects are inability

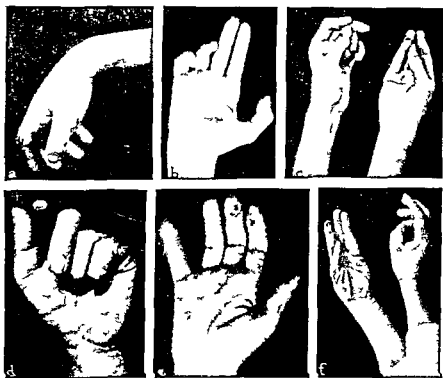


Fig. 160—*a* Wrist drop in paralysis of the radial nerve *b* clawing of inner two fingers in paralysis of the ulnar nerve *c* inability to oppose all fingertips in paralysis of the ulnar nerve *d* the left compared with the normal right hand *e* inability to make a fist in paralysis of the median nerve *f* trophic ulcers in paralysis of the median nerve *f* inability to oppose the thumb to the little finger in paralysis of the median nerve

Some of the pronounced signs of nerves most commonly injured will be described.

When the *radial nerve* is injured a position of wrist drop is seen. Often a dorsal protrusion of the metacarpal bones is seen. The patient is unable to extend the wrist, the proximal phalanges of the fingers and the thumb and to abduct the thumb in the plane of the palm. If the lesion is high enough the brachioradialis is paralyzed and if still higher he cannot extend the forearm because of paralysis of the triceps. There is a loss of sensation over the dorsal

to oppose the thumb to the little finger forming the letter 'o' because of paralysis of the *opponens pollicis* when an attempt to make a fist is made the index finger remains partly or completely extended because of paralysis of the *flexor indicis* and *flexor profundus digitorum*. The distal phalanx of the thumb remains extended because of paralysis of the *flexor longus pollicis*. The same position can be brought about by trying to interlock the fingers by clasping as in prayer. When an attempt is made to approximate all of the fingertips only the

little ring and middle fingers succeed. Abduction of the thumb at right angles to the plane of the palm is impossible because of paralysis of the abductor. Sensation is lost over the radial side of the palm, the lateral surface of the index finger, the middle finger and the radial side of the ring finger. At times sensation may be conserved in the ring and the ulnar side of the middle finger. On the dorsum of the hand there is a loss of sensation in the distal two phalanges of corresponding fingers. Because of extensive overlap pain to deep pin prick may return except over the distal phalanges of the index and middle fingers.

The position assumed by the hand in ulnar nerve palsy is that of a clawing of the ring and middle fingers because of overaction of the extensors.

What is true of motor disability because of supplementary movements in the median nerve is also true in the ulnar nerve. Among the characteristic disturbances is an inability to grasp a flat object between the thumb and index finger except by ineffective action of the flexor of the thumb because of paralysis of the adductor pollicis. There is an inability to move the middle finger laterally, the other parts of the hand being immobilized also to approximate the tips of the little ring and middle fingers and to abduct the little finger effectively. Sensation is lost over the little and the ulnar side of the ring fingers and corresponding part of the palm, the distal two phalanges of the little and the ulnar half of the ring fingers and corresponding part of the dorsum of the hand. Because of overlap pain to deep pin prick may return in all parts except the distal phalanges of the little finger.

When both the ulnar and median nerves are severed a similar and apt position of the hand results. No flexor movements of the wrist or fingers are possible and movements of the little finger are lost, the thumb can only be abducted in the plane of the palm and extended. The sensory loss is the combined ulnar and median distribution and overlap occurs only on the radial side of the palm, index and middle fingers.

Although lesions of the brachial plexus are divided into upper or lower and inner, outer or posterior cord lesions, often there are lesions of the whole plexus, part of which

recovers leaving a residuum which is then classified. In an upper brachial plexus or Erb's palsy, often seen as birth palsy, the fifth and sixth roots are involved and produce a paralysis of the deltoid, biceps and brachioradialis muscles. In lower brachial plexus lesions, also often in birth palsy, there is a paralysis as of a combined ulnar median nerve palsy, as is the case in a lesion of the inner cord. In lesions of the posterior cord there is a paralysis of the deltoid, the muscles supplied by the radial and subscapular nerves. In a lesion of the outer cord there is a paralysis of the biceps, brachialis anticus, supplied by the musculocutaneous and the muscles supplied by the median nerve exclusive of the intrinsic muscles of the hand.

When the sciatic nerve is severed there is a paralysis of all the muscles below the knee. Because the fibers to the biceps femoris, semimembranosus and semitendinosus are given off high in the thigh they are often spared. There is a loss of sensation over the outer side of the leg and the whole foot except the inner surface proximal to the sole.

When the peroneal nerve is severed the foot hangs in a plantar flexed position known as foot drop. The patient is unable to flex or extend the toes or the foot or to evert the foot. Inversion is possible by feeble action of the tibialis posterior supplied by the tibial nerve. The sensory loss extends over the outer side of the leg, a strip over the dorsum of the foot from the inner two or two and a half toes to a line in the middle of the outer surface of the great toe and the great and adjacent toe. Because of overlap at times a very narrow strip over the dorsum of the foot is the only area completely anesthetic to all sensation.

**Operative Treatment**—In a partially injured nerve when indications of continued regeneration cease or in one whose function is completely interrupted but where other evidence indicates compression rather than anatomical section, operative treatment is indicated when after a period of time (three to six months) no evidence of recovery is seen. Some operations formerly described and performed in complete section as nerve flaps, nerve implantation, tubular sutures and suture a distance have been found to be futile. An end to end suture is the best

method of repair and when impossible nerve transplants and nerve crossing are the methods of choice

When a nerve is sutured immediately or very soon after injury the operation is referred to as a primary suture. As the results of early repair are far better than those of other procedures it should be attempted in almost all instances. It is certainly indicated when a nerve is accidentally cut in operation or torn by stretching fracture or dislocation. It should also be performed in injuries sustained by gunshot wounds or stabs when no suppuration of the adjacent structures is present. Many advise it in such cases as well. Although suppuration will often interfere with regeneration no harm has been done by the suture and retraction of the nerve ends will have been prevented facilitating a subsequent secondary suture.

When primary suture is performed the injured lacerated or contused ends of the nerve should be resected until healthy funiculi are exposed. Usually these will be found a short distance from the point of injury but at times a considerable part of the nerve end must be resected. The ends of the nerve must be united as anatomically perfectly as possible that is without torsion by epineurial sutures which by some are combined with two transfixion sutures. The suture material of choice is a strand of the finest Coricelli black silk although some advise fine (000) chromic catgut. The ends should be brought together without compression and all tension avoided the epineurium must be accurately closed absolute hemostasis is necessary and greatest delicacy is indicated in the handling of the nerve so as to avoid injury. When sutured the nerve should be allowed to repose in its former bed if no trauma or scar tissue is present but if the latter condition exists a new bed should be found in the plane between uninjured adjacent muscles.

In secondary sutures the injured nerve ends on which bulbs have been formed will be found embedded in scar tissue which must be resected. To expose the nerve ends it is advisable to begin the dissection some distance from the scar or site of injury. The position of the two parts of the nerve should be identified by fine silk sutures so that axial rotation may be avoided. When it is found

that no traction on the nerve is necessary to unite the ends the bulbs should be resected with the finest and sharpest knife (for example a safety razor blade) until healthy funiculi bulge out. The ends are then approximated as in a primary suture. When because of extensive injury or retraction the ends are too far separated to permit of suture they may be approximated by flexion or extension of the extremity the ends brought as closely together as possible by fairly heavy sutures and the extremity gradually returned to its normal position thus stretching the nerve. If this procedure is successful the ends may then be sutured. If a large defect is present recourse may be made to mobilization or dissection of the nerve out of its bed for some distance beyond the point of injury. By this means at times without change of position of the extremity (flexion or extension as the case may be) the nerve ends may be approximated. At times it may be possible merely by the change of position of the extremity to approximate the ends of the nerve. Then the extremity is immobilized in that position for six weeks. Often it is possible to approximate the severed ends of the nerve by displacing the course of the mobilized nerve for example displacing the ulnar nerve at the elbow from the groove behind its inner condyle anteriorly.

The suture line as in primary suture must be protected from scar tissue by placing it in a bed in the plane between healthy muscles. If this is impossible at times Cargile membrane may be used to surround the suture. When none of these procedures suffices to permit an end to end suture nerve transplantation may be performed. In this operation a cutaneous nerve such as the superficial branch of the radial the external cutaneous nerve of the thigh etc. is removed and divided into several pieces forming a cable which is interposed between the severed ends of the injured nerve and sutured to them. When regeneration does not occur in the distal end of such a repaired nerve a resection and suture of this end may later become necessary because of the formation of scar tissue.

Irremediable defects in nerves may be treated by tendon and muscle transplantation or arthrodesis of joints. At times good

results have been described by direct implantation of a severed end of a nerve into a muscle (direct neurotization)

When a nerve has only been compressed by scar tissue or a bony callus the severed nerve may be dissected free from scar tissue and placed in a new bed. This procedure is known as neurolysis. The operation is indicated in those cases in which the lesion is chiefly extraneural and is most successful when the nerve is compressed by a constricting band. At times when the scar tissue around the nerve has been removed the nerve is found to be indurated. In such cases the sheath of the nerve must be incised (in internal neurolysis). Some of the funiculi may be found to be severed and a suture of part of the nerve may be necessary, at times because of the extent of the injury resection and suture may be indicated.

Following an injury to a nerve before operation is performed and following the operation until recovery has occurred over stretching of the paralyzed muscles and over action of unopposed muscles leading to deformities must be prevented by proper splinting. The extremities should be splinted to place the muscle at rest usually midway between its extremes of movement in either direction. Physiotherapy directed toward prevention of fibrosis capsular contraction of joints fibrosis and atrophy of muscles should be used before and after operation. This should consist of heat massage passive movement electrical stimulation of paralyzed muscles and later re-educational exercises.

LEWIS J. POLLOCK

## TUMORS OF THE PERIPHERAL NERVES

Tumors of the peripheral nerves become important clinically and surgically whenever they produce pain dysfunction or increasing tumefaction. These tumors may arise in the nerves themselves or in other tissues of the body that contain nerves or nerve filaments. In order to study tumors that occur on the extracranial and extravertebral nerves Stout Laidlaw and Haagensen suggested a classification that has been modified to permit a surgical consideration of the subject.

## TUMORS OF THE PERIPHERAL NERVES

- 1 True neuromas traumatic neuroma
- 2 Tumors involving nerve terminals neurovascular glomus tumor, pigmented mole
- 3 The specific nerve sheath tumor peripheral fibrosarcoma of Penfield neurofibroma sometimes erroneously called a neurofibroma
- 4 The nerve sheath manifestations of von Recklinghausen's disease terminal neurofibroma sheath neurofibroma plexiform neurofibroma fibroma molluscum
- 5 Questionable tumors lipoma hemangioma Pringle's disease or adenoma sebaceum
- 6 Malignant tumors fibrosarcoma neuroepithelioma, metastatic tumors

## TRUE NEUROMAS OR TRAUMATIC NEUROMAS

A tumor of this type consists of proliferation of the axis cylinder the sheath of Schwann and the fibroblastic tissue and appears on the proximal end of a divided nerve or a severely traumatized nerve in which normal repair has been prevented. The clinical history usually reveals that trauma has been followed either by pain or by loss of function. Palpation will reveal some tumefaction. The treatment is surgical and an attempt should be made to remove the neuroma and anastomose the normal nerve (Fig. 169 a and c).

## TUMORS INVOLVING NERVE TERMINALS

Glomus tumors or tumors of the neurovascular glomus are the result of hypertrophy of organs found beneath the nails in the corium of other parts of the hands and feet and in other parts of the upper and lower extremities. The tumor usually appears as a bluish or purplish subcutaneous or subungual nodule although no discoloration or projection may be detectable. A patient suffering from a glomus tumor usually seeks relief from severe pain which centers around a small area in one of the extremities. The pain is in the arm leg foot or hand the lesion occasionally is situated beneath the finger nail or toenail and the patient complains of exquisite pain which occurs at intervals or when pressure is made on the nail. The glomus is a complex of small arteries and veins composed of a sinusous vessel lined with



endothelium. *Marsson* and *Popoff* expressed the opinion that these vessels control arterio-venous circulation and body temperature. An encapsulated tumor forms in the glomus frequently affecting young and emotionally unstable women. The striking clinical characteristic is pain which occurs in paroxysms and which may attain an agonizing intensity. The pain may come on spontaneously or may be initiated by trauma, pressure changes in temperature or other causes. Although such tumors usually occur singly, two instances of multiple tumors are on record. The treatment is surgical; simple excision of the tumor is followed by immediate relief of symptoms.

**Pigmented moles** are tumors that usually are not considered with tumors of the peripheral nerves. The distinctive features of a pigmented mole are the presence of nevus cells in the dermis and the intimate connection between these nevus cells and the sensory nerves of the skin. These features indicate that the pigmented mole is a step in the evolution of sensory nerve terminals in human skin.

#### THE SPECIFIC NERVE SHEATH TUMOR (PERIPHERAL FIBROBLASTOMA OF PENFIELD, NEURINOMA, SOMETIMES ERRONEOUSLY CALLED NEUROFIBROMA)

This group of tumors comprises the single isolated tumors of the peripheral nerves which are similar in structure to the intraspinal and intracranial tumors of the nerve. Peripherally, a tumor of this type involves not only a large nerve but also many small branches. Of the large nerves which are affected the median, ulnar, sciatic and radial nerves are involved in this order of frequency. The tumor is often palpable beneath the skin and may attain considerable size without causing pain, paresthesia and paresthesia. It is always attached to a nerve in which it may be embedded. The nerve fibers, however, do not enter the body of the tumor as they do in a true neurofibroma but pass around it. The tumor as a rule is benign and encapsulated. It does not metastasize although it may recur locally unless removed completely. The growth is usually slow and although malignant change has been reported in these tumors, such a change

is more frequent in true neurofibromas. It is the consensus that such a tumor develops from the sheath of the nerve, is fibrous and has a highly specific morphologic structure which is reminiscent of tumors of the endoneurium or sheath of Schwann. It causes symptoms of pain and interference with function and often becomes soft, serous or cystic. The growth of the tumor is generally slow, periods of quiescence alternating with periods in which its size increases rapidly. The treatment is always surgical (Fig. 163) and as the tumor is encapsulated it is possible in almost every instance to excise it successfully and at the same time to spare the nerve trunk if it is of importance. It is rather safe to assume that malignant changes do not occur in this type of tumor. Microscopically, the most typical feature of this tumor is the arrangement of nuclei in zones, palisades or whorls.

#### THE NERVE SHEATH MANIFESTATIONS OF VON RECKLINGHAUSEN'S DISEASE

Neurofibromatosis or von Recklinghausen's disease is a hereditary systemic disease which involves the nerves primarily. It is characterized by single or multiple tumors on the nerves by pigmentation of the skin by *café au lait patches* (Fig. 161) and sometimes by endocrine disorders. Neurofibromas are usually palpable beneath the skin and are often painful. They may be very numerous; they may follow the course of a single nerve trunk or may be scattered.

The characteristic feature of von Recklinghausen's disease is a proliferation of the tissues composing a peripheral nerve including both the axis cylinder and its sheath. This overgrowth may take place along the course of the nerve and may produce encapsulated tumors called neurofibromas or it may produce general thickening, elongation and tortuosity of the nerve. The latter changes comprise a plexiform neurofibroma. The overgrowth may also occur about the peripheral terminations of a nerve; it may produce non-encapsulated nodules in the skin called cutaneous neurofibromas or it may cause a generalized thickening of some superficial area called elephantiasis neuro-matosa.

These tumors are encapsulated in a

smooth white fibrous covering on cross section the nerve fibers even macroscopically may be seen to enter and leave the tumor. If degeneration has taken place in the tumor its contents are likely to be gelatinous but if degeneration has not taken place the cut surface is smooth dense and shiny and on close inspection is finely granular. Microscopically the outstanding characteristic of a neurofibroma is the presence of nerve fibers which pass through the tumor. The tissue is seen to be rather loosely arranged and to contain long curving oat-shaped nuclei and bundles of collagen fibers. There may be portions in which the histologic picture resembles that of perineural fibroblastoma.

Neurofibromas may occur in any situation, they are benign and grow slowly. At times they may be painless and symptomless for many years or they may give rise to local pain and to paresthesias as a result of their size.

Heredity is an important factor as evidenced by studies conducted by Preiser and Davenport on 30 families. In 47 per cent of the cases in which one parent was affected all the children showed some signs of the disease such as pigmentation or multiple tumors. Trauma may be an exciting factor as the tumors appear at the site of a bruise or along the line where clothing has exerted pressure on the skin.

The prevalence of malignant change in these tumors was pointed out by Garre who found that it occurred in about 12 per cent of cases in his series. Courvoisier found 53 instances of sarcomatous change in 500 cases of neurofibroma of the malignant tumors, 15 were pure sarcomas and the remainder were myxosarcomas and fibrosarcomas. In the majority of cases in which tumors that have been removed are found to have undergone malignant change the tumors tend to recur locally or regionally within a year. Clinically it is difficult to distinguish between simple neurofibromas and perineural fibrosarcomas on the one hand and those in which malignant change have occurred on the other hand because within the same tumor regions of malignancy may be adjacent to simple neurofibromatous tissue. For this reason every tumor of a peripheral nerve should be examined microscopically

and when a slowly growing neurofibroma that produces but few symptoms increases rapidly in size and is associated with increased paresthesia hyperesthesia or motor changes malignant degeneration should be suspected.

The treatment of multiple neurofibromas or von Recklinghausen's disease depends a great deal on the clinical manifestation of the tumors. It would be impossible in some cases to remove surgically all the tumors

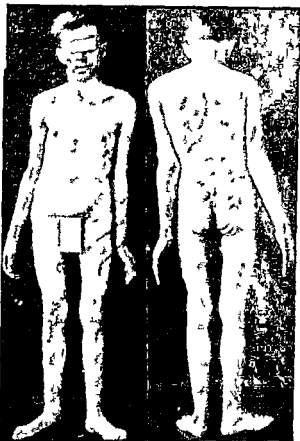


Fig. 161.—Café-au-lait spots with (A) café-au-lait spot and (B) neurofibroma producing a large excisional pit in anterior aspect of left thigh.

that are present (Fig. 161). However any of the tumors that produce pain tumor formation paresthesia or paresis should be removed surgically and the patient should be instructed not to worry about any of the other tumors unless there is a sudden increase in size or some clinical manifestation.

#### TUMORS WITH A QUESTIONABLE RELATION TO NERVES

Multiple or single hemangiomas, lipomas, fibromas, fibromyxomas, fibrosarcomas and

neuroblastomas as well as sebaceous adenomas (Pringle's disease), may be associated with other indications of von Recklinghausen's disease and their relation to tumors of the peripheral nerves is questionable

### MALIGNANT TUMORS

Malignant tumors of peripheral nerves are not common they are of the mesoblastic type and are more inclined to occur in von Recklinghausen's disease or in connection

lungs and pleurae are most commonly affected the diaphragm liver bones and neck are rare sites of metastatic involvement

The treatment of malignant tumors of the peripheral nerves is surgical although the local attempt to eradicate them may fail. Radical operation seems to be the treatment of choice. These tumors are radioresistant however radiotherapy should be used and if all types of treatment fail amputation should be resorted to.

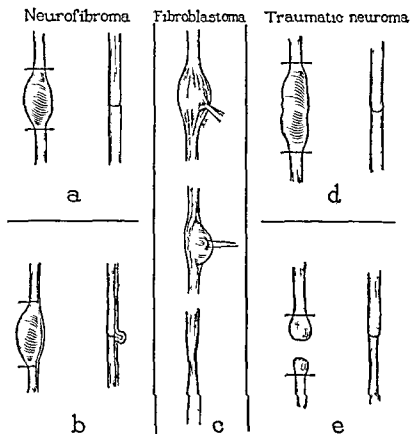


Fig 16—Surgical treatment of tumors of peripheral nerves. Diagrams representing resection and excision of tumors and anastomosis of nerves

with the neurofibromas than with the peripheral fibroblastoma of Penfield. In a small number of cases of neurofibromas and plexiform neurofibromas in which malignant change has occurred or recurrence has been noted after surgical treatment the tumors have been called malignant neurofibromas. Certain sarcomas which seem to be of neurogenic origin have been called neurogenic sarcomas.

Metastasis of malignant tumors of the peripheral nerves is not common it occurred in only 20 per cent of the reported cases. The

A rare malignant tumor of peripheral nerves which is different from a fibrosarcoma has been termed a neuroepithelioma.

Although malignant tumors often extend locally along the sheaths of the nerves they rarely give rise to distinct metastasis in nerves.

### TREATMENT

As stated previously the treatment of most tumors of the peripheral nervous system is surgical and complete excision of the tumor and involved nerves should be followed by careful anastomosis of the nerve if

indicated. However, before outlining any type of treatment for tumors of the peripheral nerves, a careful examination should be conducted. This should include serologic tests for syphilis, routine tests for tuberculosis and a careful inspection of the skin of the body. The granulomas of syphilis and tuberculosis may simulate tumors of the peripheral nerves closely, a differential diagnosis, therefore, is important. In addition, a careful neurologic examination should be

subcutaneous fat. The tumor and the attached nerve should be exposed. If the tumor seems to be in the skin (glomus tumor), it is necessary to excise only the portion of the skin containing it. Subcutaneous tumors such as lipomas, should be excised, however careful inspection of the adjacent nerve usually will determine whether or not it is involved. If a neurofibroma involves the entire nerve (Fig 162, a), it is necessary to divide the nerve above and below the tumor and

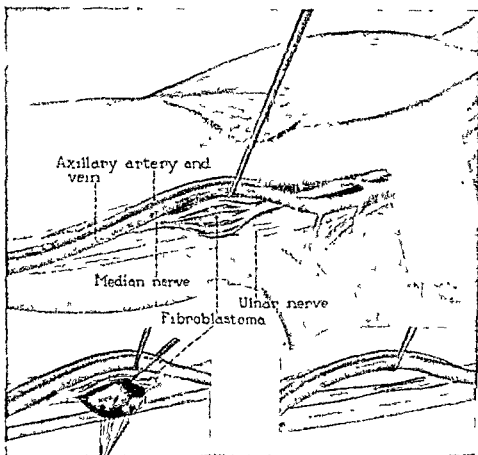


Fig 163—Perineural fibroblastoma of the median nerve before dissection and after removal

made in order to determine any definite regions of anesthesia and any atrophy or weakness of the muscles. One should make a final inspection in an effort to differentiate primary tumors of nerves and other conditions resembling them. Many of these tumors exist for years without causing any discomfort or disability. As soon as they tend to cause pain along the nerves or show any definite increase in size, they should be removed surgically and examined microscopically. Under either regional or general anesthesia, an incision should be made through the skin and

subsequently to anastomose its divided ends with interrupted silk sutures inserted through epineurium. Fine tantalum wire has been used instead of silk as a suture material and has been found to cause less tissue reaction about the suture line. Plasma glue has also been used to join the divided ends of the nerve with tension sutures of tantalum wire. This latter technic is being developed and gives promise of usefulness especially in the smaller nerves and where there is little or no tension. If only part of the nerve is involved the fibers that are involved should

be carefully dissected free from the tumor and from those that are not involved. The tumor should be excised (Fig 16<sup>o</sup> b) and the involved nerve should be anastomosed. A specific nerve sheath tumor or perineural fibroblastoma can be dissected from within the nerve fibers (Fig 16<sup>o</sup> c). Incision of the outer sheath will allow close inspection of the tumor. As soon as it can be determined that no nerve fibers enter the tumor and that there is a line of demarcation between the tumor and the surrounding fibers, silk tension sutures should be placed in the tumor and by means of traction exerted with these sutures the tumor should be dissected from its bed within the fibers (Fig 16<sup>o</sup> d).

A traumatic neuroma should be excised and the ends of the nerve approximated (Fig 16<sup>o</sup> e). A tumor arising in the divided ends of a nerve should be excised. Care should be taken that a sufficient portion of the growth is removed in order to allow for the approximation of normal looking fasciculi (Fig 16<sup>o</sup> f).

The treatment of all tumors of the peripheral nerves is surgical. It consists of complete excision of the tumor and involved nerve and anastomosis of the cut ends of the nerve wherever possible.

Recurring or malignant tumors should be treated with excision and probably with radiotherapy, although most of these tumors are radioresistant. In cases in which there is extensive involvement or recurrence the entire extremity should be amputated.

### SUMMARY

Hyperplastic growths following injury are represented by the traumatic neuromas. Hypertrophy of tissues rich in nerves probably explains the neuromyoarterial glomus. The pigmented mole has been included in the tumors of the sensory nerves of the skin. The tumors arising from the sheaths of the nerves have been designated as perineural fibroblastomas; they are benign and have a characteristic morphologic structure, but the etiologic factor is unknown. The true neurofibromas that involve both the sheaths and the nerves are part of a widespread disturbance of the nervous system that is known as von Recklinghausen's disease. A malignant tumor of a peripheral nerve usually de-

velops from a neurofibroma without any known cause.

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### TRIGEMINAL NEURALGIA

(*Tic Douloureux*, *Trifacial Neuralgia*, *Foix's Ergalgia*, *Disease*, *Epileptiform Neuralgia*, *Neuralgia Major*, *Prosopalgia*)

**Definition.**—Trigeminal neuralgia is a disease of unknown etiology characterized by paroxysmal excruciating pain of sudden onset in the area of distribution of the fifth cranial nerve which may be initiated by the stimulation of dolorogenic zones. The disease has a chronic clinical course interrupted by remissions.

**Etiology.**—This disease occurs most commonly in patients in the fifth, sixth and seventh decades of life. The youngest patient in a series of 444 cases was twenty-one years of age and the oldest eighty-three years. Of these 444 patients, 265 were females and 179 were males.

Although cases of the teeth is a disease of comparatively modern times, trigeminal neuralgia has been associated since the thirteenth century with the supposition that the teeth are involved. The treatment of trigem-

inal neuralgia is usually shared between the dentist and the physician. The pain may appear to originate in a tooth and though it is perfectly sound the patient insists on extraction. No definite etiological relationship can be established between carious teeth or any trauma which might attend their extraction and the pain of trigeminal neuralgia.

Other possible foci of infection such as the tonsils, ears and sinuses have been thought of as possible etiological agents but the removal of these infections has never been followed by lasting relief from the pain. The increased susceptibility of some persons to herpes labialis has also been investigated in relation to the occurrence of trigeminal neuralgia but without definite results.

That many of these patients have advanced signs of arteriosclerosis and that many suffer from hypertension is apparent from a study of any large series of patients but these instances are balanced by those patients whose blood pressure is within normal limits and whose arterial system is quite elastic.

Of the 444 patients with typical trigeminal neuralgia six showed definite symptoms of multiple sclerosis. Parker has described four such cases and in one found two sclerotic plaques in the pons at the point of emergence of the sensory root on the side affected. The sclerotic process extended outward a short distance within the substance of the root. The gasserian ganglion and peripheral divisions showed no pathologic changes.

Cases of the petrous portion of the temporal bone tumors or aneurysms in the cerebellopontile angle and osteomas of the middle fossa of the skull among many other diseases whose number is legion have been cited in the literature as probable etiological factors but as yet proof is lacking.

**Pathology.**—Examinations of the gasserian ganglion, portions of the sensory root and the peripheral branches of the trigeminal nerve have been made many times and by many different investigators without finding pathologic changes of significance. The lesion in trigeminal neuralgia whatever its nature may be is not a destructive one because of the absence of degenerative findings in the cells of the ganglion or in the peripheral or sensory root fibers and the total lack

of loss of sensation to any modality in the cutaneous distribution of the nerve.

The visomotor symptoms which are characteristically present during the attacks of terrific pain have led some to implicate the sympathetic nervous system but again no definite gross or microscopic pathologic lesions have been described.

The presence of tumors or aneurysms themselves producing pressure on the gasserian ganglion or sensory root would lead to definite symptoms indicative of a destructive lesion in addition to the pain which would be produced. This combination of symptoms would immediately suggest that the case was one which should be diagnosed as some other condition than trigeminal neuralgia.

**Symptoms.**—Though this painful and intractable disease of the face may have been encountered it was not described as an entity until John Fothergill wrote his monograph *Of a Painful Affection of the Face* in 1776.

The onset of the pain of this disease is sudden and unforgettable. The patient experiences a lightning like jab of pain in his upper or lower gums at the side of the nose in the upper or lower lip or on the cheek beneath the eye. More rarely the first pain may be felt in the ophthalmic area of supply. When questioned years later the patient may describe with vivid accuracy with what task he was busied at the time of the onset of the pain. One person had just sat down to a Thanksgiving Day dinner another was in the act of hanging out her freshly washed clothes and a third startled the audience and players in a theatre by her piercing scream. The initial pains are usually of very short momentary duration and are usually described by the patient as 'jabs' with a red hot poker or sharp knife. This series of pains may disappear just as suddenly as it came and the patient again feels perfectly well. If the pain occurs in the upper or lower gums it is attributed rather naturally to a tooth and in the mind of the patient this apparently localizes the pain accurately. Days, weeks, months or years later and though the guiltless tooth may have been removed the pain just as suddenly returns. The duration of the pain usually increases it may radiate to another division of the nerve and the proximum may have a climax (sometimes

likened to the explosion of a bomb within the face) but still the onset and termination are dramatically abrupt.

If the patient is examined carefully, dolorogenic zones or the trigger areas of Patrick will be found. These are areas on the skin on the mucous membrane of the cheek on the side of the tongue on the gums on the upper or lower lip at the angle of the nose in the nares or anywhere within the distribution of the fifth nerve stimulation of which will initiate a typical paroxysm of pain. These trigger zones are quite characteristic of trigeminal neuralgia and constitute one of its most prominent symptoms. A light breath of air on the cheek the slightest touch on the lip or any movement of the face such as laughing talking eating sneezing or blowing the nose will start the pain. In many cases patients cannot stand the excruciating pain occasioned by washing or shaving the affected side of the face and often one may see several weeks' collection of sebaceous secretion and dirt which has been left untouched on the patient's face. It is not uncommon to see patients who are dehydrated and emaciated because of their inability to take food or fluids without initiating paroxysms of pain the anticipation of which has seemed unbearable.

Patients behave differently during the attacks. With some the affected side of the face is screwed up tightly with the eyelids closed with others the jaw may be fixed wide open and saliva may drool from the mouth. In other patients tears stream from the eyes and they perspire freely. Some place a hand firmly on the cheek in an effort to stop the pain while some place their hand in a protective attitude beside the face but dare not touch it. Others rub the face briskly during the attack and so hard that the skin may be worn off.

The patient is usually free from paroxysms of pain at night no doubt because he is quiet and no facial movements are made. In some however the attacks continue night and day and no relief is obtained until the severity of the attack abates and an interval of freedom from the pain returns. These intervals of freedom may vary from complete relief to a condition in which the paroxysms of severe pain have disappeared and only short electric shocks of pain with long inter-

vals of freedom between are present. Some patients never lose the sensitiveness of the face even though stimulation of the trigger zones does not bring on the pain and the attacks are in complete abeyance.

The disease becomes more chronic as the years go by the intervals of freedom between attacks become shorter although the severity of the pain may have become somewhat less. Invariably the pain persists relentlessly and in former years before modern methods of treatment were known much often terminated the disease. In one instance in this series the patient seventy-two years of age suffered with the pain for thirty-six years before finding complete relief.

The pain of trigeminal neuralgia never radiates across the midline although both of the trigeminal nerves may be affected. Bilateral trigeminal neuralgia is not common however and in practically every instance several years elapse before the opposite side becomes involved. In the writer's series of cases only one case of bilateral trigeminal neuralgia has been observed.

**Diagnosis.**—The picture of agony presented by a patient suffering from a paroxysm of pain of trigeminal neuralgia is unforgettable and is not reproduced in all of its characteristics by any other disease which alone corroborates the diagnosis of trigeminal neuralgia. Stimulation of the trigger zone will produce a paroxysm of pain when the patient is in the throes of an attack. The patient commonly locates these areas for the examiner but they are not difficult to find. The remainder of the physical examination usually discloses nothing with direct bearing on the diagnosis.

The patient's story of the onset of the pain the exact location radiation and character of the pain are so striking and so definite as to be impressive. It is seldom indeed that a patient does not remember the exact situation and conditions under which the very first attack occurred and this is an important diagnostic fact.

The pain of sinus disease is not paroxysmal in character it is a heavy, severe neuralgic type of pain which occurs usually in the later hours of the day and as the sinus fills with secretion the pain becomes worse. There are no striking intervals of freedom

from pain. Toothache differs from it in many particulars but here again the paroxysmal climatic and explosive character of the pain of trigeminal neuralgia serves to make differentiation rather simple.

Glossopharyngeal neuralgia is a disease similar to trigeminal neuralgia in every respect except that it involves the ninth (glossopharyngeal) cranial nerve. The attacks of pain are alike as are the onset and course of the disease. The trigger zone is most commonly situated on the anterior pillar of the tonsillar fauces and stimulation of this area with a cotton applicator will initiate the pain. The pain is felt just below the angle of the jaw on the side of the throat and below the ear; it spreads upward toward the ear and toward the cheek. Cocainization of the trigger zone will produce almost immediate relief from pain and is an accurate method of differentiation. Swallowing and eating are the most active stimulating factors in this disease. The distribution of the pain is the one point which differentiates it from trigeminal neuralgia during the period of a paroxysm of pain.

Tumors of the gasserian ganglion or of the cerebellopontile angle and aneurysms of the internal carotid artery may produce severe pain in the face but the pain is of longer duration and does not have such an abrupt onset and termination. Moreover rather soon these lesions become destructive in nature and areas of sensory loss to one or more modalities of sensation may be found on examination of the trigeminal cutaneous distribution. As these tumors progress other cranial nerves are involved or other symptoms of intracranial tumor appear.

Deep boring pain in the maxilla and cheek has been ascribed by many rhinologists as due to neuralgia of the sphenopalatine ganglion. Cocaine solution may be placed on the mucous membrane of the nose just posterior to the middle turbinate where the ganglion will be affected and relief from the pain will serve as an accurate method of differentiation.

Though not common ticlike pains may occur in the distribution of the fifth nerve and differentiation from the type of pain alone may be impossible. A careful neurological examination of the pupil reflexes and sensation will point to the correct diagnosis.

Malignant growths of the face and mouth may by extension involve the fifth nerve and its divisions and produce a severe agonizing pain in the face but differentiation from true trigeminal neuralgia is not difficult. The sensory root of the trigeminal may be severed to give these unfortunate patients relief.

There is a group of patients who complain of pain in the face which is not characteristic of trigeminal neuralgia and trigger zones are absent. Careful search for etiological factors in these cases may not be successful and relief from the pain cannot be secured by any of the common analgesic drugs. It has become the custom to group these cases under the term of atypical neuralgias of the face because of a lack of knowledge concerning the correct diagnosis.

**Prognosis and Course.**—The course of trigeminal neuralgia is characterized by intervals of freedom from pain which are as abrupt in their onset as is the initiation of the pain. These may vary in length from days and months to years without any definite cause although it is customary for the patient to associate freedom from the pain with the last therapeutic method which has been tried. Invariably the pain returns to last an indefinite and usually a longer period of time made unbearable by a more agonizing and severe pain. As far as is known no case of trigeminal neuralgia has ever ceased spontaneously although intervals of many years between attacks have been recorded.

**Treatment.**—In an occasional case in the early part of its course when the severity of the attacks of pain is slight medicine may give relief but in the majority of patients drugs fail to control the excruciating pain of trigeminal neuralgia. The usual analgesics are of little value though in combination with other hypnotics some slight relief may be obtained. Often morphine alone does not help but in combination with hyoscine temporary relief and sleep may be produced. In some instances inhalations of trichloroethylene may be of help although it has been the writer's experience that as time goes on relief becomes less sure and complete.

Many claims have been made for the effectiveness of injections of thiamine chloride, nicotinic acid, insulin and liver extract.



over long periods of time Improvements which occur following such treatments must be carefully differentiated from natural remissions of the disease Most patients usually come to the surgeon eventually for relief

In 1890 Rose excised the superior maxilla trephined the base of the skull with the foramen ovale as a cen-

the temporal bone by means of an omega shaped flap of skin muscle, perosteum and bone This procedure was known as the high temporal operation in contradistinction to the method proposed first by Cushing<sup>2</sup> and later by Lexer<sup>3</sup> in which the line of incision was somewhat lower These suggestions concerned only the means of reaching the ganglion to excise or avulse it Because of the high mortality resulting from avulsion of the ganglion, operative procedures were limited for a time to division of the peripheral branches involved

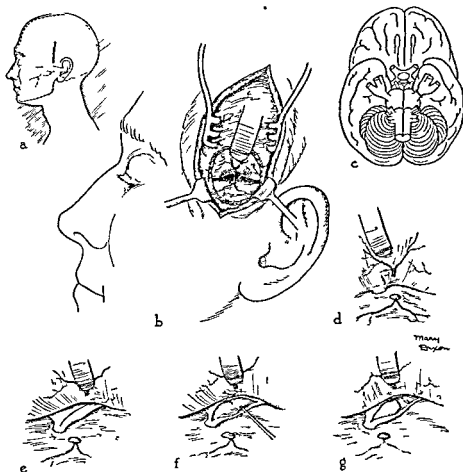


Fig 164—*a* Location for the skin incision *b* opening in the squamous portion of the temporal bone and elevation of the dura mater over the temporal lobe to expose the middle meningeal artery *c* the point of section of the posterior root between the pons and the gasserian ganglion *d* location of the middle meningeal artery and the exposure of the mandibular division in the foramen ovale *e* separation of the dura mater of the temporal lobe from the dural envelop along the ganglion and the line of incision in the envelop *f* posterior root is downward and outward to separate it from the motor root before division *g* divided ends of the posterior root posterior to the ganglion

ter and I curetted away the gasserian ganglion At about the same time the elder Edmund Andrews among others exposed and excised the ganglion through the pterygoid fossa These radical operative procedures were followed by an extremely high mortality In 1891 Horsley suggested and performed division of the trigeminal nerve posterior to the ganglion and although he stated that "the operation presented no special difficulty beyond that of being very tedious the patient died seven hours later of shock In 1892 Hartley and Krause simultaneously advocated an approach through

Such incomplete measures were almost always followed by regeneration of the avulsed nerve and by attacks of pain in one of the remaining branches so that further surgical measures became necessary

In 1901 Frazer divided the sensory root posterior to the gasserian ganglion following a suggestion made by Spiller in 1898 that the fibers of the sensory root when divided between the ganglion and their entrance zone into the pons will not regenerate It has been proved experimentally that regeneration of the sensory root never occurs after it has been divided at that point

This is the fundamental principle on which the present day surgical treatment of trigeminal neuralgia is based.

At about the time when the mortality of surgical procedures was admittedly high and when the conclusive evidence of Spiller and Frazier was not yet accepted widely, Pitres and Verger and subsequently Schlessler advocated alcohol injection of the deep foramina of exit of the three divisions of the trigeminal nerve from the skull. The effect of the alcohol is to produce a local destruction by coagulation of the nerve fibers at the point of injection. This is followed by degeneration below that point to the periphery. However, as long as the cells of origin within the ganglion are intact a new nerve fiber will begin to grow downward and conduction within the nerve may be expected to return within from a few months to two years. In addition it may be realized that injections are not uniformly successful even in the hands of surgeons who have had a wide experience.

At present surgical approach to the gasserian ganglion and sensory root is made through the temporal bone at the level suggested by Cushing and Exer. However, the incision is a longitudinal one which extends upward for about 3 inches from the pretragoid tubercle on the zygoma (Adson). A simple trephine opening is made through the squamous portion of the temporal bone and this is enlarged with bone-biting forceps. The method of making a large flap of muscle, periosteum and bone is quite unnecessary. The operative opening is enlarged downward as far as possible rather than upward, since the field is better exposed thereby and less retraction of the temporal lobe of the cerebrum is necessary. When the dura mater is raised by wet cotton sponge dissection from the floor of the middle cranial fossa it may become necessary to identify several landmarks. These are (1) the foramen spinosum through which the middle meningeal artery enters the cranial cavity, (2) the foramen ovale through which the mandibular division exists from the skull and (3) the gasserian ganglion with its sensory root. The operation is performed under local anesthesia until the ganglion is exposed. At that stage a light ether anesthesia is continued until the root is severed. The patient is awake before leaving the operating room and is relieved immediately of the pain. Total section of the sensory root brings about a sensory loss for pin prick, cotton wool touch and temperature stimuli over limited areas. (See Postoperative Care.) Deep pressure sense in the face is conserved in the facial nerve.

Recent refinements in technique proposed by Frazier,<sup>4</sup> Stookey<sup>5</sup> and others have made it possible to perform a subtotal section of the sensory root fibers. If the pain has been limited to the maxillary and mandibular divisions it may seem advisable to conserve the ophthalmic portion of the root. As Davis and Haver<sup>6</sup> have shown since the fibers of the root rotate in their course from the brain stem to the ganglion and anastomose freely at the hilus of the ganglion, it is necessary to exercise care as to the exact point at which subtotal section is performed. Otherwise fibers may be conserved in which pain has been present and relief may not be as successful as is possible. Another meeting in technique is that which conserves the motor root. This structure may be identified easily, and if the superior medial edge of the ganglion is drawn downward and laterally as Adson has suggested the motor root will separate from the overlying sensory root quite easily.

In 1932 another approach to the sensory root by a suboccipital craniotomy was suggested by Dandy<sup>7</sup> on the basis that section of approximately half of the sensory root near the pons results in complete relief of pain but with slight sensory changes in the face and that this operation often discloses small tumor masses or aberrant blood vessels which are etiological factors in the production of the pain. Experimentally and clinically it has been shown that the sensory loss from division of the root near the pons and near the ganglion is the same. Further, the possible surgical accidents which may occur to the important cranial nerves in the posterior fossa which must be exposed by a suboccipital approach is an important matter not to be regarded lightly, particularly since several serious postoperative complications of irreparable damage to the cerebellum have been observed following this operation by various neurological surgeons over the country.

Sjoquist<sup>8</sup> has proposed section of the bulbospinal trigeminal tract at the level of the lower half of the olive which produces an ipsilateral anesthesia for pain and temperature with preservation of sensibility to touch stimuli. The operation is technically more complicated than the Adson subtemporal pre-ganglionic section of the sensory root and

a frequent complication is paresis of the recurrent nerve

**Postoperative Care**—Certain conditions may be present following an operation for trigeminal neuralgia which must be explained clearly beforehand to the patient. None of the approaches in gravity the excruciating pain from which the patient suffers. In the order of their importance these conditions are (1) lesions of the cornea (2) facial paresis (3) paresthesias (4) difficulty in mastication and (5) a feeling of fullness in the ear.

Involvement of the corneal epithelium occurs as the result of a direct injury to the insensitive cornea. It is necessary therefore for the patient to exercise more than ordinary caution in the care of his eye. He should wear glasses or goggles when exposed to a strong wind or to dust and cinders. Gauze or cotton should not be used to remove foreign material from the eye because of the danger of injuring the corneal epithelium. The patient must be instructed to irrigate the eye using either an eye dropper or an eye cup with sterile water twice daily and to close his eyelids more frequently than he has been accustomed to in order to lubricate the corner with the normal conjunctival secretions. Boric acid solution and other eye washes irritate the eyes of these patients. While in the hospital the patient is instructed carefully in the care of his eye and is made conscious of the fact he must protect the cornea from gross trauma. Dressings are not used in an effort to keep the eyelid closed; they are difficult to hold in place and add a definite hazard to the safety of the cornea.

If the cornea becomes ulcerated the eye may be closed by suturing the eyelids together until the cornea is healed. However if the patient is instructed to report the moment the eye becomes red and if he is then told to keep the eyelids closed voluntarily to irrigate the eye with sterile water and to continue this simple treatment until all redness has disappeared usually within forty-eight hours all signs of inflammation will disappear.

Paralysis or paresis of the facial muscles may follow division of the sensory root of the fifth nerve and all of the facial muscles on the affected side are involved. It occurs

in about 2 per cent of the cases and may be present immediately after or may appear some days following operation. Its occurrence has been ascribed to trauma within the pons produced by avulsion of the sensory root to the slow oozing of incompletely controlled bleeding and to traction on the greater superficial petrosal nerve a branch of the geniculate ganglion of the facial nerve. The latter is the most likely and accurate explanation since this nerve crosses the petrous portion of the temporal bone and may be injured as the dura mater is raised from the floor of the middle fossa. In any case the facial weakness recovers much as does a typical Bell's palsy. Massage and electrical stimulation of the muscles of the face plus the use of small adhesive strips to keep the muscles from sagging have aided greatly in obtaining a prompt recovery.

The paresthesias complained of following operation include burning and sticking sensations in the conjunctiva of the eye a feeling described as if the face were held in a plaster cast formication numbness and coldness. It may be surmised that descriptions of the resulting sensory loss and the severity of the discomfort produced depend entirely on the mental make-up of the patient. The nervous person usually bothers a great deal about these vague sensations for several weeks or months. He becomes obsessed with the idea that the relief from his excruciating pain cannot be permanent and interprets these sensations as forerunners of an impending attack. When he is finally convinced that his paroxysmal pains will not return he soon forgets about the paresthesias.

Difficulty in mastication does not occur when the motor root is preserved and therefore there are only a few patients who complain of being unable to open their mouth as widely as before operation and of difficulty in chewing their food. There are a few instances in which it is difficult to isolate the motor root without prolonging the time of operation considerably and in a patient of advanced years one must weigh the problem carefully. Regardless of whether or not the motor root is spared many patients complain of losing particles of food between their teeth and cheek on the affected side. In view of the loss of sensation within the mouth

the explanation of this fact is easy to understand but without exception a satisfactory adjustment to this situation is made rapidly.

A rather small group of persons complain of a feeling of fullness or heaviness in the auditory canal following operation. Careful examinations of the tympanic membrane and external ear usually offer no explanation for this symptom but fortunately it soon disappears. Adson has suggested recently that it is caused by a collection of cerebrospinal fluid which escaped during the operation within the internal auditory canal.

LOYAL DAVIS

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### GLOSSOPHARYNGEAL NEURALGIA

Glossopharyngeal neuralgia is a disease which resembles trigeminal neuralgia in that the pains are spasmodic, excruciating, lancinating and radiating. However, in glossopharyngeal neuralgia the pains are projected along the distribution of the ninth cranial nerve whereas in trigeminal neuralgia they are projected along the distribution of the fifth cranial nerve. In glossopharyngeal neuralgia the trigger zone is placed in the tonsillar fossa and the darting pains are projected toward the ear usually terminating in the tympanum. The pains are precipitated by yawning, swallowing and talking but they are not precipitated as they are in trigeminal neuralgia by rubbing the face.

Weisenburg in 1910 was the first to de-

scribe the syndrome of pain produced by a tumor pressing on the ninth nerve. Oppenheim described a case in which there was paralysis of the ninth nerve and in which objectively there was thermesthesia and paralysis of the soft palate and pharyngeal muscles on the same side. He stated however that the tactile sensation was preserved. Sicard and Robinson, Harris, Doyle, Dandy, Stookey, Peet and the writer have reported experiences encountered in the treatment of glossopharyngeal neuralgia.

My first experience dates back to March 18, 1922 when a patient was examined who complained of a rather indefinite pain syndrome in the region of the tonsillar fossa, parotid area, ear and neck and for whom an injection of alcohol into the first branch had been without effect. Curiously enough the patient told us that temporary relief had been afforded when a local physician had cocainized his throat at the particular time however this phenomenon did not have a great deal of significance to us. Because the pain was severe resembling trigeminal neuralgia and involving the auriculotemporal branch and because the patient was not getting sufficient relief from palliative measures I thought we were justified in carrying out a radical operation on the fifth nerve. I subsequently divided the sensory root on March 23. The patient received the usual anesthesia that follows division of the sensory root but in spite of this there was recurrence of pain when the patient awoke about a week following the operation. The pain continued to recur until I avulsed the glossopharyngeal nerve extracranially through a lateral cervical wound on April 25. This gave the patient complete relief until June 10, 1924 when he had a recurrence. This led to discontinuance of the peripheral operation and to the employment of intracranial nerve section proximal to the ganglion which I proposed in June of 1924 and carried out on November 6, 1925.

**Etiology and Pathology.**—The etiology of this disease is just as obscure as that of trigeminal neuralgia. It is rather curious that both diseases begin in middle life or later and that they both occur in cycles, with paroxysms of pain followed by intervals of complete relief. In both diseases no definite pathologic change has been demonstrated in the ganglions. Likewise in both diseases the pain is invariably initiated by stimulation of a trigger zone. It is generally assumed that the disease is the result of some pathologic change in the ganglion itself. However it is fair to postulate that these classic attacks of pain may be the result of some circulatory phenomenon something akin to the periodic attacks of vaso-

spasm seen in the peripheral arteries in Raynaud's disease. It is barely possible, too, that these circulatory attacks, recurrent attacks of pain, may be the result of some allergic disturbance. The pains are so severe that they cannot be of functional origin and must be the result of a chemiopathologic disturbance in the central nuclei rather than in the peripheral ganglions of the nerve. One would like to look on both glossopharyngeal neuralgia and trigeminal neuralgia as a disease of the peripheral nerves, a type of neu-

tonsillar fossa. The pains are brought on more often by yawning and swallowing than by chewing and cannot be brought on by rubbing the face, only occasionally are they brought on by rubbing the ear. Glossopharyngeal neuralgia also differs from trigeminal neuralgia in that the pain is projected from the tonsillar region and pharynx through the neck to the ear, particularly to the tympanum. In glossopharyngeal neuralgia it will be observed that cocaineization of the pharynx will result in temporary cessation

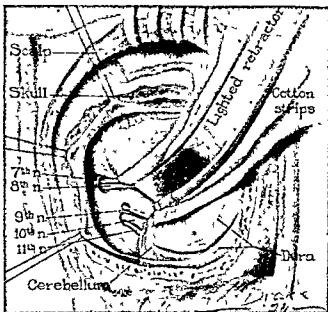


Fig 165—Retraction of the cerebellum with lighted retractor exposing the seventh, eighth, ninth, tenth and eleventh cranial nerves

ritis, if this were true, however, then one would naturally expect to find definite paresthesia and anesthesia before any operative intervention, which evidence is lacking.

The temporary relief that follows cocaineization and extracranial avulsion is faintly suggestive that the disease is of peripheral nerve origin. The recurrence of pain with regeneration of peripheral fibers indicates that the seat of pain is not in the peripheral fibers. They carry afferent impulses to set off the painful reflex which includes spasm of the pharyngeal muscles and arteries.

**Symptoms and Differential Diagnosis.**—The pains resemble those of trigeminal neuralgia in their occurrence, duration, repetition and character, but they differ from those of trigeminal neuralgia in their distribution. The trigger zone is situated in the

of all attacks, but it will not alter the paroxysms when they are due to trigeminal neuralgia.

**Palliative Treatment.**—Injection of alcohol cannot be used in the palliative treatment of glossopharyngeal neuralgia, as it is used in the treatment of trigeminal neuralgia, since the ninth nerve is too intimately associated with the tenth and eleventh cranial nerves and the cervical nerves and with the cervical sympathetic chain. Therefore, the only temporary procedure that has offered any palliative relief at all has been peripheral avulsion. Peripheral avulsion of the ninth nerve is a rather formidable procedure, and it is one that the writer has discontinued since the intracranial procedure can be carried out without any difficulty and it assures permanent relief.

At the onset of this disease most patients are not prepared to accept a formidable operation. It is therefore necessary that patients thoroughly understand the problem. They should be told that the paroxysms of pain will return and that permanent relief can be obtained by intracranial nerve section. Sedatives such as bromides, phenobarbital and trichlorethylene have a tendency to decrease the severity of the attacks. It is unwise to advocate continued use of morphine. If palliative measures fail to furnish relief, the radical procedure should be advised.

**Technic of Intracranial Division of the Glossopharyngeal Nerve.**—The exposure used is that of unilateral suboccipital decompression. The patient is anesthetized through a Magill intratracheal tube with ether and then placed on a cerebellar upright frame. A straight lateral scalp incision is employed. The skin and muscles are reflected in the same manner as they are for cerebellar decompression and the bone covering the one cerebellar lobe is rongeuired away. The dura is incised along the outer and inferior borders of the decompression. If the cerebellar lobe does not displace easily, one can drain the posterior cistern. Before elevating or displacing the cerebellar lobe, it is well to cover the dura and cortex with strips of cotton. The lobe of the cerebellum is then elevated with an illuminated retractor which exposes the seventh and eighth cranial nerves inferior to these and slightly more superficial the ninth, tenth and eleventh nerves will be seen entering the jugular foramen (Fig. 165). On closer observation the ninth and tenth nerves will be found to be short and to pass at right angles from the medulla, whereas the spinal accessory nerve is longer and will be seen to enter the foramen in an oblique course from below upward. The glossopharyngeal nerve enters the foramen at the rostral margin and is separated from the vagus nerve by a small dural band which is less than 1 mm. in width but which is definite enough to distinguish the ninth nerve from the tenth and to permit one to pass a small right angled Langdon knife between the fibers of the glossopharyngeal and vagus nerves allowing for sharp section of the glossopharyngeal nerve without injury to the vagus.

**Results.**—Pain is instantly and permanently relieved after intracranial section of the glossopharyngeal nerve. The sensations of taste on the one side of the tongue detected by the circumvallate papillae are lost. Tactile pain and thermal sense is lost in the upper half of the nasopharynx including both sides of the soft palate and tonsillar pillars. Since the motor innervation of the stylopharyngeus muscle has been included the soft palate will be seen to retract to the unoperated side. Immediately after operation the patient may complain that fluids return through the nose during the act of swallowing but he soon learns to overcome this. Their appreciation of the relief from pain appears to make the patients forget about the anesthesia for rarely do they complain of any discomfort.

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### SCIATICA

The term sciatica has come to include all painful conditions about the hips and thighs or any lesion that produces projection of pain along the sciatic nerve. Since sciatic pain may result from any number of lesions it is apparent that the origin of this pain must be located before any attempt is carried out to treat the condition.

The projection of pain along the sciatic nerve frequently accompanies hypertrophic arthritis and contractures of the iliotibial band. It is usually a common and persistent symptom in sacroiliac disease. It is frequently found to be an early symptom of tumor arising from the nerve roots of the cauda equina and in the filum terminale. The pain produced by intraspinal tumor is rather characteristic as it appears after the patient has been reclining for from four to six hours and disappears when he rises and walks about. As the tumor grows pain will be associated with loss of reflexes and with impairment of sensory and motor functions. Sciatic pain may result from anomalous bony and cartilaginous lesions of the lumbosacral portion of the spine, pelvic tumors, metastatic lesions in the lumbar portion of the spine and pelvic bones, neurofibromas within the sciatic nerve itself and vascular disease of the legs and feet due to thromboangitis obliterans and arteriosclerosis.

**Protruded Intervertebral Disk as an Etiologic Factor**—The cartilaginous lesions referred to in recent literature as protruded intervertebral disks or rupture and prolapse of the nucleus pulposus into the spinal canal appear to be the most common cause of recurring chronic sciatica. Although the lesion has been encountered for years I operated on my first patient with this condition in 1922. It was not recognized and diagnosed preoperatively until opaque oils were introduced into the spinal canal and were observed under the fluoroscope. In these cases roentgenographic findings revealed a filling defect in the column of oil opposite the lesion owing to the bulging mass produced by the protrusion of the nucleus pulposus. This protrusion compresses the nerve root between the cartilaginous mass and the bony structures surrounding the intervertebral foramen. The fourth and fifth lumbar roots on one or both sides are usually involved

and give rise to unilateral or bilateral extension of pain from the lumbosacral region along the course and distribution of the sciatic nerve.

The symptoms produced by this condition may vary in intensity depending on the character of the protrusion of the nucleus pulposus of the intervertebral disk. At the onset the protrusion may be small owing to the fact that only a few fibers of the annulus fibrosus have been ruptured but as recurring attacks take place more fibers are ruptured and a large bulging mass protrudes into the spinal canal. If attacks of sciatic pain continue to recur eventually the greater portion of the nucleus pulposus will have prolapsed through the annulus fibrosus and will give rise to a group of continuous symptoms. Injuries to the spinal column such as acute anterior flexions of the spinal column are common causes for the rupture of the annulus fibrosus and the partial or complete prolapse of the nucleus pulposus. This condition may result from a jump or fall in which the person lands heavily on his feet or buttocks. They also result from 'lifting' accidents in which a person feels something snap when he is lifting a heavy object. However it is surprising to encounter a goodly number of patients who complain of recurring attacks of sciatica but have not sustained any injury as far as they know. This phenomenon is probably explained by the presence of weakness in the annulus fibrosus, the ligamentous band which holds the intervertebral disk in place. This weakness which is due to thinness in the ligament is located on the dorsolateral surface lateral to the midline and lateral to the posterior longitudinal ligament since this is the site of most of the protrusions (Figs 166 and 167).

Pain is the characteristic phenomenon and often does not appear until hours following the injury. It consists of darting stabs in the lumbosacral region and usually is associated with muscular spasm and scoliosis with a shift of the trunk to the opposite side. In the more advanced cases pain extends along the course of the sciatic nerve. It gives rise to tenderness along the nerve and patients not infrequently complain of muscle cramps in the calf of the leg with darting pains extending to the outer surface of the foot. If

protrusion of the nucleus pulposus is almost complete, adjacent nerve fibers, usually those of the fourth and fifth lumbar nerves, may be compressed. This compression may give rise to involvement of sacral nerves and in turn to paresthesia along the anus and over the perineum, with disturbance of bladder and rectal functions. Small protrusions

control the pain. Undoubtedly many small injuries of the annulus fibrosus with protrusion heal spontaneously. However, when recurrent attacks continue to appear, it is evident that sooner or later a portion of the nucleus pulposus will ultimately prolapse through the rent in the ligament without prospect of spontaneous recovery.

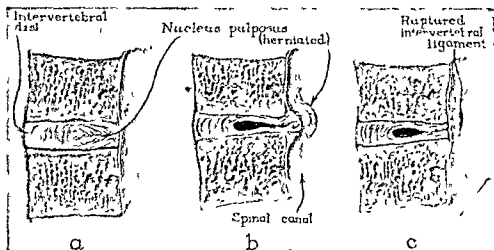


Fig 166.—The mechanics involved in the rupture of the intervertebral disk with prolapse of the nucleus pulposus; a, a normal intervertebral disk; b, prolapse of the nucleus pulposus into the spinal canal; c, appearance of the ruptured intervertebral disk following removal of the prolapsed nucleus pulposus.

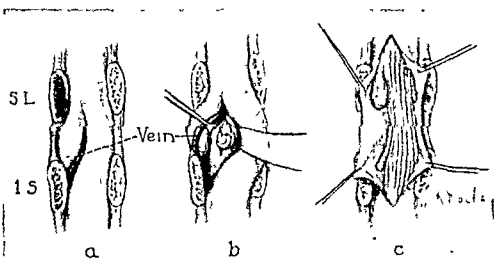


Fig 167.—The trauma and the resulting edema which develops within the compressed nerve root from the protrusion of the intervertebral disk.

sions of the nucleus pulposus usually give rise to short bouts of sciatica. Diminution of the symptoms is undoubtedly due to recession of the nucleus. This recession can be accomplished by placing the patient on a bed with a firm mattress and by using Buck's extension. Local heat will relieve the muscular spasm, and mild anodynes will

The neurologic symptoms, therefore, consist of localized pain situated in the lumbosacral region with extension of pain along the course of the sciatic nerve, subjective or objective paresthesia and anesthesia, depending on the size of the protruding cartilaginous mass. When the larger lesions are present, the achilles tendon reflex is im-



paired or absent Lasegues and Kernigs signs are always present. Muscular spasm in the lumbar region is usually present and is frequently associated with scoliosis and a limp. Studies of the spinal fluid frequently reveal an increase in the concentration of protein to more than 40 mg per hundred cubic centimeters. However if the lesion is of long standing the spinal fluid may be normal.

**Differential Diagnosis.**—Although protruded intervertebral disks are a common cause for chronic recurring sciatica they are not the only cause of sciatic pain and in making a differential diagnosis the symptoms produced by neoplasms of the pelvis, neoplasms within the spinal canal and those



Fig 168.—Roentgenogram illustrating a filling defect in the lipiodol opposite the intervertebral disk between the fifth lumbar and the first sacral vertebra due to rupture of the disk with prolapse of the nucleus pulposus.

of the peripheral nerves, skeletal system and muscles must be kept in mind. Then too infections cannot be disregarded. Occasionally neuritis has developed though it is rather unusual when the sciatic pain is unilateral. Hypertrophic arthritis is not an uncommon cause for sciatic pain. However pain resulting from hypertrophic arthritis is usually not recurrent but continuous in contrast to the pain produced by a protruded disk which is characterized by recurrent rather than continuous attacks. The pain in the latter condition becomes continuous only when the nucleus pulposus has prolapsed through the rent in the annulus fibrosus and is unable to replace itself within the disk.

The history of injury, low back and sciatic pain associated with muscular spasm, scoliosis, an impaired achilles tendon reflex and a positive Lasegues sign is almost pathognomonic of a protruded intervertebral disk. These symptoms and signs are so characteristic of the lesion that the surgeon is justified in exploring the fourth and fifth lumbar disks surgically without myelographic studies. Of course it is needless to say that for every patient who complains of a group of symptoms suggestive of protrusion of a disk or fusion a thorough history, careful physical, laboratory and neurologic examinations and plain roentgenograms of the lumbosacral portion of the spinal column are required. In order to protect the patient further against errors in diagnosis consultations should be held by the orthopedic surgeon, neurologist and neurosurgeon since it is not infrequent that the orthopedic surgeon suggests a bone graft for the lumbosacral region in conjunction with removal of the protruded portion of the nucleus pulposus in order to support the spinal column when there are bony anomalies such as spina bifida occulta, sacralization of the fifth lumbar vertebra, early spondylolisthesis and active hypertrophic arthritis. Studies involving spinal puncture are of value but are not always necessary unless combined with a myelographic study. They are of course indicated if an intraspinal tumor is suspected.

**Myelographic Study.**—The use of opaque oils such as lipiodol and pantopaque in fluoroscopic studies are distinct diagnostic aids (Fig 168). However since there is some suspicion that these oils may give rise to irritation to the meninges and nerve roots they should be removed following the roentgenologic study. Since this procedure subjects the patient to a rather prolonged examination under the fluoroscope the pneumomyelogram is employed in most cases at the Mayo Clinic. For the pneumomyelogram the cerebrospinal fluid is replaced by oxygen. The filling defect produced by the protruded disk is visualized in about 75 per cent of the cases. The test is not as accurate as the one in which the opaque oils are used. However there are certain advantages in using the pneumomyelogram since the procedure can be carried out

much more quickly than that in which opaque oils are employed, as it is not necessary to prolong the examination by removing the oxygen or air. Pantopaque and occasionally lipiodol are employed when there is considerable doubt as to the presence and size of the protrusion or when a legal question is raised as to whether or not a protruded disk resulted from a given injury in an industrial accident.

**Treatment.**—The treatment for a protruded disk which is responsible for recurring attacks of sciatica is its removal. This is accomplished by one of two methods. In the beginning of this sort of surgical treatment, bilateral lumbar laminectomy was considered necessary. However, the usual

important not to injure the nerve root, to control hemostasis and to avoid injury to the dura and arachnoid (Figs. 169 and 170).

Since acute and chronic infections may be responsible for perineuritis and periradicularitis, as well as for the various types of arthritis, it is extremely important that thorough eradication of all foci of infection be accomplished. Heat in the form of hot packs, dry heat or diathermy usually is effective in controlling pain, but it is less effective, of course, when pain is due to tumor. Roentgenotherapy has been tried but has offered little or no relief.

Epidural injection for pain of the ganglionitis type is fairly successful and can be repeated innumerable times, depending on

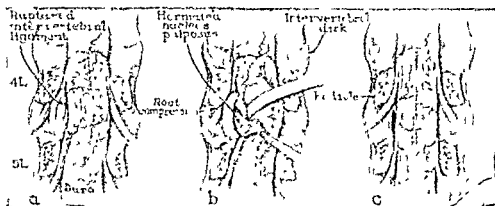


Fig. 169.—The compression of the nerve root by the protrusion of the nucleus pulposus into the spinal canal and the relief of compression when the mass has been removed: *a*, protrusion of the nucleus pulposus through a rent in the intervertebral ligament, compressing the lumbar nerve root; *b*, removal of the ribbon-like fibrocartilaginous nucleus pulposus; *c*, relief of compression of the nerve and dura following removal of the fibrocartilaginous mass.

type of laminectomy now employed consists of removing the ligamentum flavum at the interlaminar space over the lesion with subtotal unilateral laminectomy. This type of laminectomy consists of no more than the nibbling away of sufficient bone, that is, the lower border of the lamina above the lesion and the upper border of the lamina below the lesion to such extent that a finger can be introduced through the opening. This procedure affords ample space to retract the dura and nerve root in order to uncover the protruded mass prior to its removal. Love has frequently found that the removal of the ligamentum flavum has been sufficient to uncover and remove the protruded mass. In carrying out the operation, it is extremely

the relief obtained. During this period, while injections are being administered, foci of infection are eradicated and local heat is applied. The only explanation one can give of the beneficial effects of epidural injection is that novocain produces anesthesia, which of course relieves the pain temporarily and allows muscular spasms to subside. It is hardly possible that forceful injection of a fluid substance into the epidural space may result in some breaking down of adhesions about the dorsal ganglion, thus relieving some of the irritating influences which give rise to pain.

Sciatic pain due to sacroiliac disease is treated not only by removal of foci of infection but by the application of a sacroiliac

belt The pain is further ameliorated by the use of diathermy In severe cases patients require hospitalization during which time Buck's extension is applied to the lower extremities and a lumbar sling is placed under the lower part of the back to reestablish the proper lumbar curve Similar radical measures may be necessary to control sciatic pain resulting from hypertrophic arthritis

Ober in discussing low back pain with sciatic extension emphasized that contractures of the ilial band result from postural influences such as lying in bed for long periods during a serious illness He stated that they also result from unusual abduction and rotation of the hips such as those that

body If there is any abduction contracture the leg will remain more or less passively abducted depending on the shortening of the iliotibial band This band can be easily felt with the examining fingers between the crest of the ilium and the anterior aspect of the trochanter

Ober has advised two types of treatment for contractures of the iliotibial band which he and others believe are frequently responsible for low back pain and low back pain with sciatic extension When the symptoms are those of low back pain alone he stated that the symptoms may be relieved by stretching exercises carried out in the following manner



Fig 170—Photograph of specimen removed at operation (nucleus pulposus)

result from a frog like position maintained by certain orthopedic measures The diagnostic symptoms of contractions of the iliotibial band are limitation of motion muscle spasm tenderness over the lumbosacral and sacroiliac regions and posterior to and just below the greater trochanter sciatic scoliosis limitation of straight leg raising positive Ely's sign and functional scoliosis if the abduction contracture is unilateral

Ober suggested that the method of performing the test for abduction is as follows

The patient lies on his side with the thigh next to the table and flexed enough to obliterate any lumbar lordosis The upper leg is flexed at a right angle at the knee The examiner grasps the ankle lightly with one hand and steadies the patient's hip with the other The upper leg is abducted widely and extended so that the thigh is in line with the

The patient stands with the affected side about  $9\frac{1}{2}$  feet away from a table or some other convenient object which he grasps with one hand then, with his shoulder and pelvis in the same plane he bends the affected hip toward the table as far as he can his whole figure forming an arc His position is maintained for a few seconds and then repeated five times the first day and is increased once each day until the exercise is done twenty five times twice a day

In those cases in which there is a severe sciatic operation is indicated and the method of procedure is as follows

1 An incision is made from just below the crest of the ilium down to the tip of the trochanter directly over the contracted iliotibial band

2 The fascia lata is exposed forward as far as the anterior superior spine and backward to the edge of the gluteus maximus muscle The area of the greatest contracture of the fascia can be seen readily and felt easily

3 The fascia is now divided transversely from just below the anterior superior spine to the anterior border of the gluteus maximus muscle There is immediate separation on the cut edges for a distance of from  $\frac{3}{4}$  to 1 $\frac{1}{2}$  inches depending on the amount of contracture present If the operator now attempts to carry out the test (for abduction) described it will be shown that the thigh will completely adduct

In reporting the results obtained by the treatment suggested Ober reviewed the data concerning 340 patients treated by other surgeons and 75 patients treated by himself Of these 415 patients 84 (about 21 per cent) obtained no relief 17 (4 per cent) showed only partial relief and 314 (75 per cent) obtained complete relief The symptoms were relieved immediately or after intervals up to one year The average time before relief took place was about three months

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## TUMORS OF THE SYMPATHETIC NERVOUS SYSTEM

Embryologically the sympathetic nervous system is derived from the medullary epithelium by way of ganglionic crest cells which migrate outward to the sites of future ganglia and plexuses. In the course of this process the cells themselves undergo a series of developmental changes from primitive undifferentiated cells, through the types

spoken of as sympathicoblasts (sympathogonia) and neuroblasts and give rise to both the adult sympathetic ganglion cells and the chromaffin tissue of the body. This latter is located for the most part in the medulla of the adrenal gland but is found as well in the so called carotid, aortic and coeliac glands. Certain chromaffin cells are also scattered throughout the lower ileum and in the large bowel as the so called "gelben Zellen" of the crypts of Lieberkuhn. In view of this rather complicated pattern of development it is perhaps not surprising that one may find elements of varying degrees of maturity in the tumors arising from the sympathetic nervous system or chromaffin tissue.

## NEUROBLASTOMA

(Sympathicoblastoma Sympathogonioma)

A neuroblastoma is a highly malignant tumor arising from the undifferentiated primordium of the autonomic and chromaffin systems occurring predominantly in infancy and early childhood. Several of the reported cases having been congenital. Eighty seven per cent of Lewis and Geschichter's own series of 40 patients were under fifteen and about half were less than three years of age. On the other hand Rittler and Meltzer have reported 3 instances of this tumor in persons over forty. By far the commonest site of the original growth is the adrenal gland, but such tumors have also been encountered arising from the paravertebral sympathetic chain, in the thorax, in the uterus or the upper jejunum and in connection with the coeliac ganglion.

Pathology.—The primary growth in neuroblastoma is occasionally very large but from adrenal tumors so small that they appear merely as a bulging of the gland while spread metastases reaching considerable size may originate. The larger tumors are nodular and firm and are surrounded by a thin layer of fibrous tissue. They are very vascular and on cross section are glistening white with an admixture of the various chromatic changes of old hemorrhages or of necrosis. Microscopically they are for the most part composed of small cells about the size of lymphocytes containing relatively large nuclei, certain of which tend to be arranged in the characteristic rosettes. The cytology

is often mixed, comprising more mature elements, such as ganglion cells, and the degree of malignancy conforms roughly to the immaturity of the predominating cells. Metastases, occurring first by the lymphatic route in the neighboring nodes, are later found in the liver and more distant organs, including the skeleton.

**Symptoms and Signs.**—The commonest findings include an abdominal mass, which may be the tumor itself or a very markedly enlarged liver, fever and anemia. However, from the accumulated cases several clinical types may be recognized which depend somewhat on the site of the original growth, but more especially on the extent and dis-

tribution of the metastases. These, the so-called Hutchinson's syndrome is characterized by swellings involving the bones of the skull, unilateral or bilateral exophthalmos and discoloration about the eyes, and, more rarely, signs of an intracranial lesion including papilledema, convulsions, seizures or paralysis. An abdominal tumor may be felt but is not a feature of this syndrome. Necropsy in these cases usually shows a retroperitoneal neuroblastoma, most often originating in the left adrenal gland with widespread metastases to the skull and other intracranial structures.

In the second syndrome, as described by Pepper, the most prominent finding is a markedly enlarged liver, with syn-



Fig. 171—Neuroblastoma

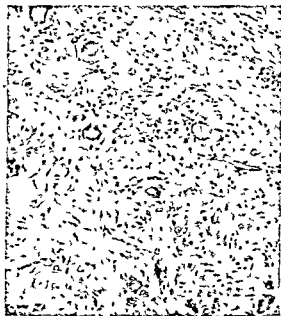


Fig. 172—Ganglioneuroma

tribution of the metastases. Thus, in a small number the adrenal gland may be largely replaced by the growth, producing a picture of Addison's disease with asthenia and cutaneous pigmentation. In another group the tumor, arising in the thorax from the paravertebral chain, may enter the spinal canal, producing the syndrome of a mediastinal or hour glass tumor. In other instances the syndrome may simulate acute rheumatic fever, with high fever and multiple joint involvement.

The two pictures encountered most frequently were originally described as due to sarcoma, before the true nature of the tumor causing them was recognized. The first of

forms referable to the abdomen. Necropsy most commonly shows a tumor arising in or near the right adrenal gland with massive infiltration of the liver.

**Course and Treatment.**—These tumors are rapidly fatal, only a single patient having been successfully operated upon, and in this instance the tumor was still confined to the adrenal gland. Radiation is usually ineffective, although softening and shrinking of the tumor may follow its use in some cases.

#### GANGLIONEUROMA

This relatively benign tumor originating from sympathetic ganglions is found usually along the paravertebral chain, either in the

chest or abdomen Heuer and Andrus were able to collect reports of 68 cases in which the growth was intrathoracic It is encountered most often in children about three fourths of the patients being in the first decade of life The tumor is well encapsulated and of firm consistency gray on section with irregular lobulation it is relatively avascular The tumor may reach considerable size to measure as much as 17 cm in largest diameter and to weigh 2 kg Microscopically it is seen to be composed of rather coarsely arranged fibrous tissue nerve fibers both medullated and non medullated and multipolar ganglion cells The latter vary in number in different tumors and many of them show signs of degenerative changes such as vacuolization

The gangliomas are for the most part benign but like the other tumors of this group may contain such a variety of cells that they must be regarded as potentially malignant Clinical experience confirms the difficulty of estimating the future course from the gross appearance Thus these tumors have been known to be present for sixteen years before being successfully removed and in other cases incomplete extirpation has failed to cause recurrence In still other instances however metastases have occurred in lymph nodes soft parts and bones In at least one case the tumor was found distributed diffusely in the subcutaneous tissue

**Symptoms and Signs**—Despite the very considerable size which they may attain the ganglioneuromas grow quite slowly and produce but few symptoms save for those of pressure on the ganglions or nerves from which they arise such as a Horner's syndrome or absence of sweating in a given zone Since a variety of tumors may press upon nerves or ganglions however the diagnosis is rarely made before operation or necropsy

**Treatment**—In view of the uncertain course operation on these tumors is advisable whenever their presence is suspected

### PARAGANGLIOMA

These tumors springing from that branch of the neuroblast tree which gives rise normally to the chromaffin tissue of the body are the most common of all the tumors of the sympathetic nervous system They appear most frequently in the medulla of the

adrenal body in the carotid body and in the appendix cecum and small intestine as the so called carcinoid or argentaffin tumors The microscopic pictures vary widely but in each group certain characteristics are discernible

**Tumor of the Carotid Body**—Tumor of the carotid body represents one of the most important tumors of the sympathetic nervous system not because of its frequency since it is by no means common but rather because it is usually recognized and being relatively superficial has been frequently attacked surgically Rather rare in patients under twenty these tumors are seen most often in patients from forty to sixty years of age Usually the growth is gradual one of the reported tumors having been present for thirty years before being removed but many patients have noted a more rapid increase in size of the tumor in the months preceding treatment

**Symptoms**—This tumor is usually symptomless until it causes pressure upon the surrounding structures such as the neurovascular bundle or neighboring nerves This may occur with even comparatively small tumors the vagus being most commonly involved and then in order of frequency the hypoglossal cervical sympathetic glossopharyngeal and spinal accessory nerves

**Pathology**—Grossly the carotid body tumor is firm nodular and of even consistency throughout with the cut surface presenting a yellowish or orange color varying to red depending on the vascularity A well defined fibrous capsule is usually evident The neighboring lymph nodes may be attached to the tumor but are seldom invaded by the growth Microscopically two general topographical patterns predominate in one of which the cells are arranged in strands or alveoli while in the other the cell growth is so intimately arranged about blood vessels that it is spoken of as perithelioma In both types the cells themselves contain a relatively large amount of eosinophilic cytoplasm and one or more dark staining nuclei Giant cells are also observed and in many instances active mitosis irregular cell growth and even invasion of the capsule can be seen Approximately 50 per cent of these tumors must be considered as malignant

**Diagnosis**—A tumor of the carotid body

should be suspected when there is a single, smooth, non-tender mass located at the bifurcation of the carotid artery, more movable laterally than vertically. To these signs may be added in some cases a transmitted pulsation and bruit and thrill, as well as signs of pressure on some of the neighboring nerves. The carotid artery is usually displaced laterally and comes to lie in a groove on the outer aspect of the tumor.

**Treatment**—The ideal treatment of a tumor of the carotid body is complete surgical removal, a procedure which is complicated in about 50 per cent of the cases by the necessity of removing also a segment of the carotid artery. Almost all the deaths in

cept for the complications of interruption of the internal carotid, cures are the rule. Recurrences or metastases are quite rare.

**Pheochromocytoma.**—Of recent years attention has been drawn to certain paragangliomas, the so-called pheochromocytomas, of the adrenal medulla which are composed of mature chromaffin cells of a type capable of producing adrenalin. The clinical course in these cases is characterized by intermittent attacks of hypertension associated with other constitutional symptoms, such as precordial pain, tachycardia, pallor or flushing and profuse perspiration. The picture may simulate that of hyperthyroidism and attacks are occasionally precipitated by



Fig 173—Malignant carotid body tumor

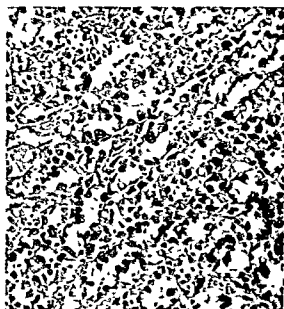


Fig 174—Pheochromocytoma

recorded cases have followed ligation of this vessel and have been due to cerebral ischemia. Before undertaking the extirpation of the tumor, therefore, every effort should be made to prevent such complications through the application of intermittent pressure for increasing lengths of time to the artery proximal to the tumor, until the patient can tolerate obliteration of the vessel for a long period without faintness or loss of consciousness. In a smaller number of cases the jugular vein must also be sacrificed, and still more rarely the vagus nerve will be found involved in the growth. These tumors are usually quite radioresistant, but x-ray has been effective in a few of the reported cases.

The surgical results are excellent, and ex-

pressure in the region of the tumor. These tumors may occur at any age but are rarely seen in children.

**Pathology**—Pathologically the tumor is usually well encapsulated but extremely vascular. The cells have clear or eosinophilic cytoplasm, with small round nuclei and a distinct affinity for the chrome stains. A high content of adrenalin can often be demonstrated by means of physiological tests.

The tumor is rarely palpable and since it is found bilaterally in about 15 per cent of cases, the localization may depend on operation although perirenal air injection may be helpful by demonstrating a rounded mass in the region of the adrenal gland.

Heuer and Marshall were able to collect

reports of 108 such cases from the literature up to 1941, in most of which the tumor had been found at autopsy, but at least 30 of the patients had been operated upon and the tumor successfully removed in 24 instances. While these cases present many difficulties, the treatment is unquestionably surgical and has produced spectacular results in some cases.

**"Carcinoid" Tumor.**—Obendorfer, in 1907, separated a group of neoplasms from the true carcinomas of the gastrointestinal tract and gave them the name of "carcinoids." These are believed to arise from the "gelben Zellen" described by Schmidt and occur most often in the appendix, where they are found once in every 200 to 500 operations.

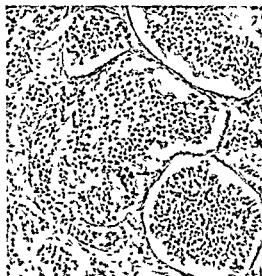


Fig. 175—Carcinoid of the appendix

Less often they are encountered in the small bowel or even in the stomach. The location of the growths is of some importance, since those of the small bowel are definitely more malignant, while the appendiceal carcinoids are benign.

In the appendix the tumor appears as a localized swelling of a part of the organ, the overlying serosa being pale and smooth. The cut surface is light yellow, with gray interlacing strands. The larger tumors involve the muscularis, and in the cases of malignant carcinoid tumor, the serosa may be invaded, with the production of obstruction by kinking of the bowel. In the intestine there is a marked predilection for the terminal ileum, and in many instances multiple primary tumors are found. Metastases occur in about

25 per cent of the cases of intestinal carcinoids.

Since no characteristic clinical picture accompanies the presence of these tumors, the exact diagnosis is almost never made before operation is undertaken for what was considered to be chronic appendicitis or, in the case of the carcinoids of the small bowel, intestinal obstruction.

The treatment is resection, for all these tumors must be considered as malignant even though of a low degree. Recurrence of appendiceal carcinoids is rare, but this is not the case with those arising elsewhere in the intestinal tract. Here the chances of metastases are particularly great when the growth has reached relatively large size and has infiltrated all layers of the bowel wall.

WILLIAM DEW ANDRUS

## THE AUTONOMIC NERVOUS SYSTEM

Surgery of the autonomic nervous system did not develop with the earlier knowledge of its anatomy, but with an understanding of the function of the craniosacral and thoracolumbar systems of nerves which has been built up by physiologists since the time of Claude Bernard.

The modern neurosurgeon stands particularly in debt to W. H. Gaskell and J. N. Langley of Cambridge University, to François-Franck of Paris and to Walter B. Cannon, professor emeritus of physiology at Harvard. He is especially indebted to the Cambridge physiologists for the knowledge of the finer arrangement of the autonomic nervous and also for the classification of these nerves into two opposing systems: the craniosacral or parasympathetic system on the one hand and the thoracolumbar or sympathetic system on the other. The latter leaves the spinal cord only between its first thoracic and second lumbar segments, while the former is given off from the brain stem and the sacral segments. The antagonistic action of these two divisions is most clearly expounded in Cannon's book on *The Wisdom of the Body*,<sup>1</sup> which every student who is interested in the subject should read. Cannon is chiefly responsible for the investigation of medullary-adrenal activity, as well as the discovery of sympathin, a second sympathomimetic hor-



more which is produced at the nerve endings on smooth muscle. The clinical significance of chemical mediators of autonomic nerve impulses is just beginning to appear and will

pathetic chains for the relief of angina pectoris.

Surgeons of the present generation have applied these fundamental physiologic prin-

### INNERVATION OF Periph Blood Vessels

### INNERVATION OF VISCERA Sensory and Motor

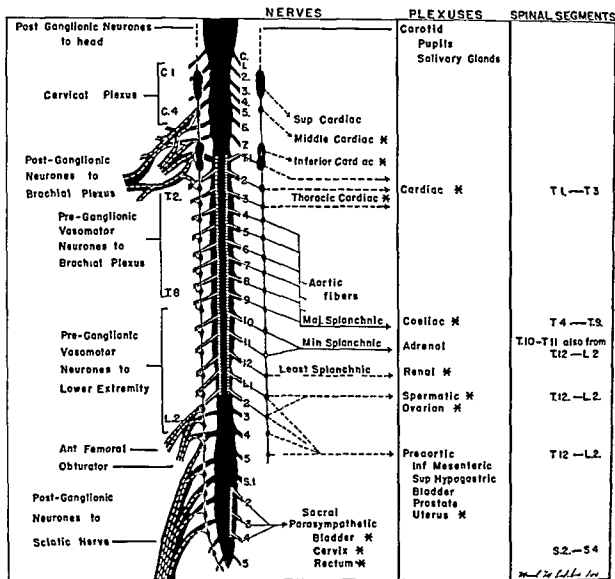


Fig. 176—The outgoing vasomotor and locomotor fibers to the extremities from the lateral horn of the spinal cord are illustrated diagrammatically on the left side. On the right side are shown the mixed motor (sympathetic) and sensory (posterior spinal root) fibers together with the principal visceral plexuses which they supply and the spinal segments from which they are derived. Preganglionic sympathetic axons are indicated by continuous lines and postganglionic by interrupted lines. The asterisk indicates the presence of pain fibers running to the posterior roots.

be discussed later. While Gaskell and Langley were investigating the motor activity of the visceral nerves, François Franck first conceived of their importance in pain and urged surgeons to remove the cervical sym-

pathetic chains for the relief of angina pectoris. Surgeons of the present generation have applied these fundamental physiologic prin-

prain. By regarding each case of sympathectomy as an experiment in human physiology, certain surgeons have contributed a practical understanding of the subject far beyond the limits of laboratory investigation.

The development of surgery of the autonomic nervous system has been so rapid that much of what was written in the previous editions of this book has had to be revised. Among the most valuable general volumes on the subject are Hovelacque's<sup>2</sup> superb textbook on neuroanatomy and Kuntz's<sup>3</sup> monograph on the pathologic physiology of the autonomic nervous system. The most useful surgical monographs have been written by Gask and Ross,<sup>4</sup> Livingston<sup>5</sup> and White and Smithwick.<sup>6</sup> A still more recent description of operative methods has just been prepared by White for Pilcher's new volume on neurosurgical operative technique.<sup>7</sup>

**Clinical Methods of Study.**—Accurate diagnostic tests have made it possible to determine in advance the effect of a proposed operation and to establish exactly which structures are to be resected. These tests depend on two fundamental principles: (1) inhibition of sympathetic activity by an appropriate stimulus such as raising the body temperature, to observe the degree of vasodilatation which results and (2) temporary paralysis of the sympathetic ganglia or their rami with procaine.

**Body Heating Tests.**—An effective method of abolishing vasoconstrictor tone is to raise the body temperature by enclosing the patient's trunk in an electrically heated cabinet with the hands or feet protruding into the cool air of the room (Lewis and Pickering). A still simpler way is to immerse the forearms or legs in hot water and to determine the vasodilator response which follows in the opposite exposed extremities (Landis and Gilbon).

All of these tests depend on the fact that when the body needs to eliminate heat it does so in large part by radiation. Blood is shunted through the subcutaneous vascular bed particularly in the hands and feet. These vasomotor adjustments are mediated by the sympathetic nervous system but cannot take place in the presence of clattered peripheral arteries. The fundamental factor in the quantitative estimation of vasospasm of neurogenic origin is not the total rise in the temperature of a given digit which depends in large part on its initial temperature but on how nearly it approaches the normal vasodilatation level. Morton and Scott<sup>8</sup> have proposed this term and placed its lower limit at approximately 87° F. (90° F. seems to the writer a fairer figure). They have further suggested

terms of the occlusion index, i. e., the maximum surface temperature recorded subtracted from the normal vasodilatation level. In typical cases of Raynaud's disease the occlusion index is 0 whereas in arteriovenous the very slight vasodilator response falls far short of the normal level.

**Diagnostic Nerve Block with Procaine.**—A third type of test was proposed by White<sup>9</sup> and by Morton and Scott.<sup>8</sup> It consists of the temporary paralysis of the sympathetic nerves with procaine. This can be most easily accomplished by injecting the mixed peripheral nerves at their most accessible points, i. e., the posterior ulnar nerve at the internal malleolus or the ulnar under the medial epicondyle at the elbow. Since the vasoconstrictor supply to the arteries is given off segmentally from the mixed nerves, complete vasodilatation

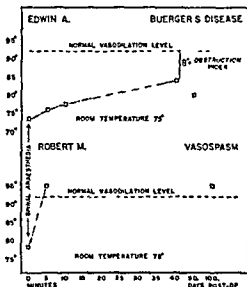


Fig. 177.—Spinal anesthesia test. The first patient Edwin A. suffered from arterial occlusion due to thromboangiitis obliterans. In addition to this, there was a distinct element of vasospasm. Definite improvement followed lumbar ganglionectomy.

The response shown by the second patient Robert M., is typical of excessive vasoconstrictor tone. This patient was relieved of all symptoms by lumbar ganglionectomy.

tion will develop in the anesthetic zone. In doubtful cases spinal anesthesia is the most certain method of insuring complete vasomotor paralysis in the legs (Fig. 177) and paravertebral injection of the uppermost thoracic sympathetic ganglia in the case of the upper extremities. For the investigation of obscure painful syndromes, such as causalgia, or unusual types of visceral pain paravertebral injection can give a selective block of the sympathetic pathways. From the response to these tests it becomes possible to select certain cases for treatment by alcohol injection or sympathectomy without recourse to the more mutilating procedures of cutting posterior roots or the sympatholaminar pathways in the spinal cord. Procaine block constitutes the most accurate form of diagnostic test and should be used in all doubtful cases.

**Treatment of Vasospasm of Neurogenic Origin**—The arteries are far from being a set of rigid tubes but constantly vary their caliber for the maintenance of homeostasis. The autonomic nervous system constitutes the mechanism by which these changes are regulated. In certain pathologic states this autonomic adjustment is thrown out of balance and a chronic state of vasoconstriction or dilatation results. The former situation is seen in Raynaud's disease and acrocyanosis. It frequently plays a contributing role in thromboangitis obliterans and in post-trau-

digital arterioles while the pulsating vessels at the wrist and ankle usually maintain their normal volume. The color changes are one of the most striking signs of the disease. These consist of varying shades of cyanosis which are present most of the time. As the disease advances attacks of blanching digital asphyxia make their appearance on exposure to cold. This Raynaud's phenomenon is probably due to the onset of endarteritic changes in the digital arterioles.\* The color pattern is extremely symmetrical (Figs 178 and 179). Usually all the fingers with the

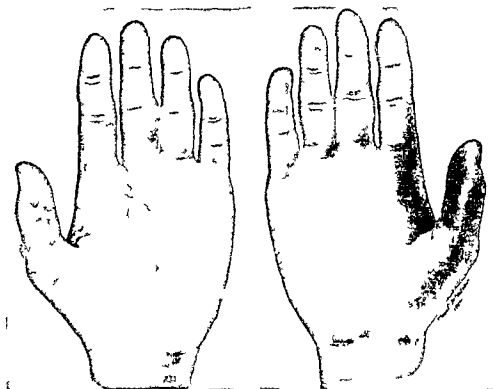


Fig 18—Raynaud's disease. Note the dead white appearance of the fingers in the stage of digital asphyxia.

matic painful states of the extremities. In severe polyomyelitis it may be the cause of trophic ulceration. By far the most common and important of these conditions is Raynaud's disease.

**Raynaud's Disease**—This malady was first described by Maurice Raynaud<sup>10</sup> in 1862; many excellent descriptions have followed, one of the best being that of A. W. Allen.<sup>11</sup>

Raynaud's disease is a form of peripheral vascular disturbance caused by spasmodic contraction of the smaller arteries in the extremities. The vasospasm involves only the

possible exception of the thumbs are involved and most often the toes to a similar extent. In a sufficiently warm environment

\*I can see no purpose in differentiating between classical Raynaud's disease described in this definition and such allied vasospastic conditions as acrocyanosis. In the former cyanosis alternates with pallid asphyxia while in the latter the extremities are constantly blue as well as abnormally cold. The palms and soles in addition to being cold and discolored are usually moist from excessive sympathetic stimulation of the sweat glands. Both conditions have a common underlying cause and both can be relieved surgically by cutting the vasoconstrictor pathway, provided secondary endarteritis or scleroderma has not complicated the picture.

the circulation becomes normal. Each case however has a critical thermal level below which the extremities react like those of a cold blooded animal and fall to room temperature. In the severe case recovery of normal circulation is slow and incomplete even in a warm room. As a result the patient lives in a constant state of discomfort and partial digital asphyxia. In the digital arteries which show no histologic changes in the early stages of the disease a form of obliterating endarteritis may develop. Painful ulcers slowly appear at the tips of the fingers and sclerodermatous changes develop

dicneephylon. On the other hand Sir Thomas Lewis<sup>12</sup> as a result of some extremely interesting observations has arrived at a diametrically opposite viewpoint. He maintains that the vasomotor tone is normal but that the peripheral vasospasm is due to an oversusceptibility to cold inherent in the smooth muscle of the digital arterioles. It is quite impossible in the brief space allotted to this subject to discuss this controversy here. Suffice it to say that everyone who has made a careful study of the advanced cases agrees with Lewis that the arteries eventually become definitely abnormal and that the dis-



Fig. 170—Raynaud's disease. The left figure shows the stage of severe attack. There are also moderate sclerodermatous terminal scarring of the second and third fingers of the right hand and excessive perspiration.

in the skin. In the advanced cases terminal dry gangrene gradually leads to necrosis of the distal phalanges and a functionally useless hand. The disease is ten times more common in women than in men. It most frequently appears in the decade following puberty and is most often encountered in persons of a nervous emotionally unstable type.

The etiology of Raynaud's disease is unknown. Most authorities have felt that the peripheral vasospasm is due to an overactivity of the vasoconstrictor nerves possibly imposed by the autonomic centers in the

order cannot then be fully rectified by paralyzing the vasomotor nerves. Lewis' contention that the sympathetic nerves are not hyperactive is quite another matter—the commonly associated overactivity of the sweat glands is a strong argument against any such conclusion. From a long study of the early stages of the disease from the observation in three cases of a mild form changing into a severe one after emotional trauma and from the complete abolition of vasospasm in the feet after lumbar ganglionectomies (which Lewis has not taken into account) the writer cannot help but feel that the sym-

pathetic nervous system plays the predominant role in the causation of this disease.

In differentiating Raynaud's malady from other types of peripheral vascular disease special emphasis should be laid on the importance of symmetrical involvement and the persistence of the peripheral pulsations. Asymmetrical color changes or ulceration should arouse a suspicion of thromboangitis obliterans if present in young males and of arteriosclerosis in patients over fifty or in diabetics. In all cases the presence of cervical ribs which at times cause confusing vascular disturbances should be ruled out roentgenographically.

From the therapeutic angle there are no safe effective vasodilator drugs. In rare cases in which the basal metabolism is low thyroid extract should be tried and may be of value. Artificial fever induced by injections of foreign protein will occasionally cause early ulcerations to heal. The same can be said for periarterial sympathectomy.\* Unfortunately the improvement from these procedures is usually short lived. Surgical intervention must be sufficiently radical to insure complete interruption of the vasoconstrictor fibers to the extremity. This requires an attack on the paravertebral chains of sympathetic ganglia which run along the anterolateral aspect of the thoracic and lumbar vertebrae.

Operative measures designed to interrupt vasoconstrictor tone must take into account the general physiologic principle that when efferent sympathetic fibers degenerate the denervated smooth muscle is rendered hypersensitive to sympathomimetic hormones such as adrenalin and sympathin. This phenomenon of sensitization may be so intense after the postganglionic fibers (the lower sympathetic neurons which run from the regional ganglia to the digital arterioles) have

\*A great deal of controversy has arisen over this operation which has been advocated by Lenche. Extensive investigation has shown that while the nerve supply of the visceral arteries runs along their sheaths that of the peripheral vessels is given off in a segmental manner by the mixed somatic nerves. There is no sound physiology evidence to defend the view that denervation of a peripheral artery can specifically influence the volume of its vascular bed. Any operation however destroys a certain amount of tissue which in being absorbed produces a foreign protein reaction and thereby a generalized vasomotor response. This may be detected for a week to ten days.

been cut that little clinical improvement results. On the other hand when preganglionic fibers (the upper sympathetic neurons running from the lateral horn cells in the spinal cord to the paravertebral ganglia) are severed it is barely noticeable. It has been a common observation that the results of resection of the lumbar sympathetic trunk are uniformly satisfactory, whereas after the older form of cervicothoracic ganglionectomy the circulation in the hands although improved often remains inadequate. White, Okelberry and Whitelaw<sup>13</sup> have pointed out that this divergent response to apparently similar procedures lies in the anatomical arrangement of the sympathetic fibers to the upper and lower extremities (Fig. 176). As the postganglionic neurons to the sciatic nerve originate in the lowest lumbar and upper sacral ganglia only the preganglionic neurons are divided by resecting the second and third lumbar ganglia. After cervicothoracic ganglionectomy on the other hand the entire postganglionic network to the arm degenerates and the vascular tree is rendered highly sensitive to circulating vasoconstrictor hormones.

To obviate this extreme degree of sensitization Smithwick<sup>14</sup> has devised a modified type of sympathectomy for the upper extremity. This consists of an approach through the resected central end of the third rib followed by extrapleural exposure and division of the paravertebral sympathetic trunk beneath its third thoracic ganglion. This interrupts all preganglionic vasoconstrictor fibers below this level (they originate from the second as far down as the ninth thoracic segment) but leaves intact a few which emerge over the second and third intercostal nerves. These are interrupted by resecting the central end of these structures. In so doing it is important to cut the nerves within the intervertebral foramina central to their bifurcation into anterior and posterior roots and preferably within the rachnoid. Only by so doing is it possible to divide all emerging preganglionic fibers with certainty as well as to prevent their extraordinary tendency to regenerate. Even after these precautions we have found cases in which nerve regeneration has taken place. To avoid this source of late failure Smithwick<sup>15</sup> has advocated covering the first and second thoracic

ganglia freed up in the preceding steps of the operation by a sleeve of fine silk and burying the protected distal stump in the second intercostal muscle. In this way the decentralized cervicothoracic ganglia which give rise to the postganglionic neurons to the brachial vascular tree are preserved but are protected from the ingrowth of regenerating preganglionic fibers by a dense capsule of scar tissue.\*

For the lower extremity the second and third lumbar ganglia should be resected. This can be carried out either transperitoneally through a midline incision which permits a bilateral resection at one stage or retroperitoneally through a modified renal incision. In either case the retroperitoneal space behind the cecum or sigmoid is entered and the lumbar chain is exposed in the gutter formed by the outer edge of the vena cava or aorta, the vertebrae and the psoas muscle. Under ordinary circumstances the extraperitoneal posterior incision is safer and preferable.

In experienced hands the risk from thoracic and lumbar ganglionectomy is remarkably slight. The chief essentials to justify such radical operations are accurate diagnosis and the demonstration by procaine injection or other diagnostic procedures that an adequate degree of vasodilatation will ensue. Under these circumstances thoroughly satisfactory and lasting improvement has followed resection of the second and third lumbar ganglia in a large series of patients with Raynaud's disease treated at the Massachusetts General Hospital. The permanent benefit in circulation of the hands has been far less satisfactory but is constantly improving. Replacement of cervicothoracic ganglionectomy by the preganglionic operation was the first important advance. The earlier patients submitted to this procedure had a most satisfactory circulation at first but a small number suffered recurrences at six to nine months from regeneration of vasoconstrictor activity. Since the adoption of the silk cylinder technique to prevent regenerating fibers from reaching the decentralized cervicothoracic ganglia regeneration has become an infrequent complication. Satisfactory results

may therefore be anticipated in the early and complicated cases of Raynaud's disease. With severe attacks of digital blanching and ischemia or in advanced scleroderma where endothelial changes have already occurred an adequate recovery of circulation cannot be expected.

*Thromboangitis Obliterans (Buerger's Disease)*—This disease although primarily due to arterial occlusion is frequently associated with and aggravated by vasoconstrictor spasm. By this mechanism the all-important collateral vascular bed is reduced. Improvement in circulation and relief of symptoms usually follow its release by lumbar sympathectomy even in cases in which no immediate improvement can be demonstrated by diagnostic procaine block. In the absence of actual gangrene but with a critically low pedal circulation or complicating intermittent claudication it has become the practice in the Peripheral Vascular Clinic at the Massachusetts General Hospital to perform a lumbar sympathetic ganglionectomy\* in the younger group of patients if the femoral pulse has not been obliterated. A significant reduction in the number of major amputations has resulted. However in the presence of painful digital ulceration or incipient gangrene it is better first to crush the peripheral nerves above the ankle as advocated by Smithwick and White.<sup>13</sup> This operation is far more efficient for relieving pain and can be counted on to cause maximal vasodilatation for a period of several weeks. If adequate collateral circulation fails to develop lumbar ganglionectomy can be carried out at a later date with the assurance of reproducing a corresponding degree of vasodilatation which will be permanent.

*Postjaralytic Cold Extremities with Ulceration*—In numerous patients with poliomyelitis as well as other types of spinal cord injury cold cyanotic extremities with ulceration develop. These have responded well to sympathetic ganglionectomy provided the paralysis was not too great but in extremities in which all muscular activity has disap-

\* There is no good evidence that any vasoconstrictor fibers to the upper extremity leave the spinal cord above the second thoracic nerve.

\* To secure the maximal increase in circulation in the upper leg the first lumbar ganglion also will be removed along with the second and third but if this is true on both sides the power of ejaculation will be lost and the male patient rendered sterile but not impotent.

peared total elimination of vasoconstrictor tone is not likely to restore a normal circulation

**Rheumatoid Arthritis**—Great interest was aroused eighteen years ago by Rowntree and Adson's<sup>16</sup> report that certain cases of polyarthritis with involvement primarily of the fingers, wrists and ankles and with accompanying vasospasm could be improved by sympathectomy and the restoration of a normal peripheral circulation. In the writer's hands two such cases have been most disappointing and few other clinics have corroborated the original enthusiastic reports.

**Hyperhydrosis of Nervous Origin**—Excessive perspiration limited to the palmar surfaces of the hands and feet is occasionally seen in young and nervous persons of either sex. While the condition is rare it may be extremely annoying and even incapacitating in certain occupations. This type of sweating may become so intense under nervous strain that beads of water drip from the fingers. As a result it becomes embarrassing to shake hands, papers are wet in handling and when rubber gloves are worn they become filled with sweat. The same condition may also involve the feet with the result that the socks and even the shoes are constantly wet through. Under these circumstances the skin becomes foul smelling, macerated and a prey to fungus infections. Psychotherapy, radiation or local applications fail to give relief but the results of sympathectomy are invariably satisfactory and frequently give dramatic psychic as well as local benefit.

**Pain in Extremities Secondary to Vaso-spasm**—Pain in the arms and legs after trauma and amputation is unfortunately an all too common complication especially after war wounds. This usually takes the form of cutaneous hyperesthesia in the scar or amputation stump or a deep aching or burning sensation which runs up the limb especially when it is cold. This condition is most commonly seen in individuals with cold cyanotic moist extremities and can usually be relieved by interruption of the underlying vasospastic state. The literature and a number of striking examples have recently been reviewed by White.<sup>17</sup> It is evident that the pain is not transmitted by the sympathetic nervous system but is in some way related to the inadequate circulation.

Even temporary restoration of a normal blood flow by paravertebral procaine block of the regional sympathetic ganglia may clear it up especially if repeated on a number of occasions. When pain is relieved but recurs as the vasodilator response to procaine disappears thoracic or lumbar sympathectomy can be counted on to give lasting relief.

**The Autonomic Nervous System and the Regulation of Blood Pressure**—The regulation of blood pressure for the varying demands of the body with changes in external and internal environment is mediated by the autonomic nervous system. The central control lies in groups of cells situated in the medulla and diencephalon. Trauma, encephalitis and tumors which injure these areas occasionally produce profound changes in the vasomotor tone. An important peripheral mechanism for the reflex regulation of blood pressure and heart rate has been found by Heymans and his co-workers<sup>18</sup> to lie in the aortic nerves and in the carotid sinus. The latter which has nervous connections with the vagus, the cervical sympathetic and the medulla through a branch of the ninth cranial nerve may become hypersensitive and produce an interesting clinical syndrome. Weiss and his associates<sup>19</sup> have reported observations on 30 patients who suffered from spontaneous attacks of dizziness, weakness and unconsciousness with or without convulsions in whom mechanical stimulation over the bifurcation of one or the other carotid artery promptly induced an attack. Depending on the efferent pathway involved three forms of this carotid sinus syndrome are found: (a) cardioinhibitory, (b) vasodilator and (c) cerebral. The first type is due to a vagal reflex and can be abolished by atropine; the fall in arterial tension can be prevented by ephedrine but the cerebral variety can be treated only by denervation of the sinus. Numerous patients with spontaneous epileptic seizures induced by slight pressure on an irritable sinus have been relieved by operation.

The paroxysmal profound alterations in blood pressure which are caused by tumors of the adrenal medulla have been discussed in the preceding chapter. These are abolished by removal of the tumor.

A third and by far the most important

abnormality in the regulation of blood pressure is seen in essential hypertension. While the cause of this condition remains unknown it has now been established beyond any doubt that surgery has something to offer the hypertensive patient. Of suitably selected patients under fifty (and preferably under forty) who are free from permanent renal damage and who still have a labile blood pressure which falls with complete rest and sedation it is to be expected that a high percentage will have a persistent and significant lowering of blood pressure and relief from their symptoms after radical sympathectomy.\* The proof that vasoconstrictor fibers to the lower half of the body have been interrupted is established when there is a profound fall in blood pressure as the patient stands. Under these circumstances regression of excoriated changes, decrease in the size of the heart, improvement in the electrocardiogram, increase in renal function and relief of symptoms are noted. Reports from many sources have demonstrated that the hands of the clock can be set back at least a number of years in the majority of younger hypertensive patients, but sufficient time has not yet elapsed to determine the exact increase in life expectancy.

The most reasonable explanation for the decrease of arterial pressure which follows sympathectomy in hypertensive subjects is the general reduction in tone of smooth muscle in the denervated vascular bed and the elimination of neurovascular reflexes which occur in the viscera, muscles and skin in response to psychic stimulation and homeostatic adjustments. In general the lowering of blood pressure observed has been directly proportional to the extent of the sympathectomy and inversely proportional to the severity of the disease. The operations in current use vary considerably in their extent. They fall into three main groups: (a) supradaphragmatic ganglionectomy and

splanchnicectomy as employed by Peet and his colleagues; (b) the subdiaphragmatic operation of Allen and Adson<sup>1</sup> and (c) the combined more radical thoracolumbar denervation of Smithwick. Both of the first two procedures are open to the objection that they do not completely denervate the lower half of the body and it is furthermore very unlikely that the limited length of splanchnic fibers that can be removed from beneath the diaphragm is sufficient to prevent regeneration. In the postoperative results reported by Peet in 51 per cent of the patients a satisfactory reduction in blood pressure developed in Adson's case a similar improvement is reported in less than 40 per cent. In the hands of other surgeons results after the less complete operations have not been impressive.

The combined thoracolumbar approach of Smithwick<sup>2</sup> permits the removal of a great length of the splanchnic trunks as well as of the ganglionated chylons from the ninth thoracic down through the first or second lumbar segments. Provided the splanchnic resection is complete to the level of the seventh or eighth ribs and the sympathetic trunk is removed to a point below the second lumbar\* ganglia sympathetic vasoconstrictor impulses to the abdominal viscera as well as to the muscles and skin below the umbilicus should be abolished (Fig. 176). A most significant point is that before adopting this somewhat more extensive procedure Smithwick<sup>2</sup> had tried the more limited operations above and below the diaphragm. His results in these were not as satisfactory as those recorded in the reports of their advocates but with the adoption of the combined operation in 1938 a significant improvement took place. In his last statistics Smithwick<sup>2</sup> has summarized the results in 156 hypertensive patients studied for a period of one to five years. These he divides into five groups on the basis of the postoperative fall in diastolic pressure. In 61.5 per cent of the entire series comprising groups 1 and 2 the diastolic pressure fell

\* Although the above constitute the most rigid requirements for insuring a satisfactory reduction in blood pressure, Smithwick (personal communication) has had a large percentage of successful results in patients in the upper forties and even over fifty as well as in others whose blood pressure failed to fall on sedation. Some of the very best results have been obtained in spite of very high apparently fixed diastolic pressures which did not respond to either rest or sedation.

\* It is important to point out that if the sympathetic chains are resected bilaterally below the level of the first lumbar ganglia the male patient will be sterilized. While potency and the sensation of orgasm are not lost, viable spermatozoa can no longer be ejaculated.



over 20 mm with an average reduction of 61 mm systolic in two thirds and 44 mm diastolic in the remaining one third. In group 3 in which the reduction in blood pressure was probably also significant there was an average reduction of  $\frac{27}{15}$  mm. This group constitutes an additional 18 per cent of the total. In groups 4 and 5 which contain the remaining one fifth of the series there was no significant change. The mortality rate amounted to 2.8 per cent. Favorable changes in eye grounds, electrocardiograms and renal function together with an improvement in the well being of the patient suggest that lowering of the blood pressure sets up a gen-

erally to the terminal visceral plexuses without synapses in the ganglia. It is therefore best to think of them as displaced somatic fibers and to call them the visceral afferent nerves. Studies of the conduction of pain from the internal organs have demonstrated two main types of afferent conduction.

1. Referred pain of the type described by Head<sup>3</sup> and Mckenzie.<sup>4</sup> This theory assumes that visceral afferent impulses run only as far as the posterior horn of the spinal cord. It is further postulated that impulses reaching this region from a diseased organ set up an irritable focus and thereby reduce the sensory threshold to stimuli from the surface of the body. As a result the constant bombardment of afferent impulses from the

TABLE 4—SENSORY INNervations OF THE VISCERA

Organ	Superficial areas to which pain is referred	Visceral ramus which carries pain
Heart	Precordium and inner arm	T <sub>1</sub> —T <sub>3</sub> or T <sub>4</sub>
Lung	No evidence of pain until parietal pleura and intercostal nerves are involved	
Esophagus	Substernal distress	T <sub>5</sub> —T <sub>6</sub> *
Liver and gallbladder	Right upper abdominal distress with pain referred to right scapular region	T <sub>7</sub> —T <sub>8</sub>
Stomach	Epigastric region	T <sub>6</sub> —T <sub>8</sub>
Small intestine	Umbilical region	T <sub>9</sub> —T <sub>10</sub>
Colon	Suprapubic region	T <sub>11</sub> —T <sub>12</sub>
Kidney	Loin and groin	T <sub>1</sub> —L <sub>2</sub>
Ureter	Loin and groin	L <sub>1</sub> —L <sub>2</sub>
Bladder	Suprapubic region penis and perineum	T <sub>9</sub> —L <sub>2</sub> also S <sub>1</sub> —S <sub>2</sub>
Uterus	Suprapubic region and lower back	T <sub>12</sub> —L <sub>2</sub>

\* Not all of the patients of esophageal pain are known

eral improvement and a reversal of the degenerative vascular changes which take place in hypertension. How long the present five year cures are to last still remains uncertain.

**Sympathectomy for the Control of Visceral Pain.**—The classic conception of the autonomic nervous system is that its pre-ganglionic and postganglionic neurons are purely the regulators of visceral activity. In the earlier studies little attention was paid to larger myelinated nerve fibers which originate from cells in the posterior root ganglia. These cells send dendrites to the posterior horn of gray matter in the spinal cord and axons through the sympathetic plexuses to the internal organs. These axons run di-

rectly to the terminal visceral plexuses without synapses in the ganglia. It is therefore best to think of them as displaced somatic fibers and to call them the visceral afferent nerves. Studies of the conduction of pain from the internal organs have demonstrated two main types of afferent conduction.

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skin which normally fail to reach the level of consciousness become magnified into painful sensation. This type of pain is sharp; it is not necessarily localized over the organ in question but is often referred to such a distant area as the medial side of the hand in angina pectoris. This occurs because some of the cardiac ramus enter the spinal cord at the same level as the ulnar nerve. Weiss and Davis have shown that pain of this sort is abolished by infiltrating the cutaneous area of reference with novocain.

2. Direct transmission of visceral pain. Over fifty years ago Ross<sup>5</sup> wrote that in addition to sharp well localized referred pain a diseased organ might also cause a deep ill defined sense of discomfort. He called the

latter "splanchnic" or "direct" visceral pain. This important contribution was lost sight of in later years, but there is good evidence that visceral pain may reach the thalamus without any referred cutaneous mechanism, because it can be evoked in animals and in human beings after all cutaneous afferent impulses have been interrupted. This direct type of sensory conduction presumably transmits the dull aching form of visceral pain which is vaguely localized to the region of the diseased organ.

inal viscera over the vagus nerves, but this is an important pathway for pain transmission from the upper part of the trachea and esophagus.

From a knowledge of these mechanisms it is obvious that pure visceral pain can be interrupted by destroying either the regional sympathetic ganglia or their rami. Section of the posterior spinal roots or the contralateral spinothalamic tract (cordotomy) will also produce a loss of visceral sensation. The two latter procedures, however, because of

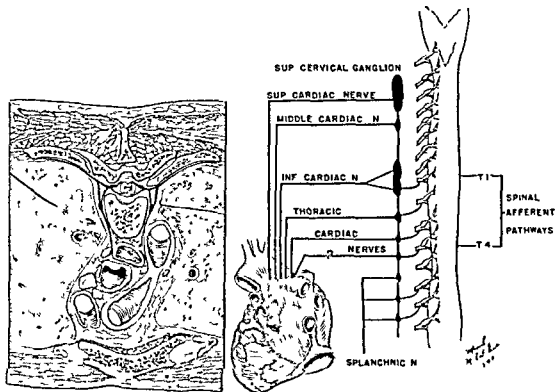


Fig 180—The sympathetic cardiac nerves. Diagram showing why cervical sympathectomy often fails to relieve pain from the heart. The operation does not interrupt the recently discovered thoracic cardiac nerves. These carry sensory impulses from the posterior cardiac plexus directly to the upper thoracic ganglia. It is questionable whether a connection from the fourth thoracic ganglion ever exists. From clinical evidence this must be very rare. Destruction of the upper three thoracic ganglia or the upper four pairs of posterior spinal roots results in complete sensory denervation.

Whenever an inflammatory or neoplastic process spreads from a viscus to the neighboring parietal pleura or peritoneum, the intercostal nerves become the chief pathway for conduction of pain, e. g., in pleurisy, appendicitis or cholecystitis with local peritoneal involvement. This is also the case in carcinoma of the lung and is the reason why sympathectomy usually fails to give relief.

No form of pain is known to reach the sensorium from the heart, lungs or abdom-

inal viscera over the vagus nerves, but this is an important pathway for pain transmission from the upper part of the trachea and esophagus.

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can be resected surgically or destroyed by alcohol injection. The method of treating cardiac pain by paravertebral alcohol injection has been described by White.<sup>26</sup> It is by far the safest method of treating pain in



Fig 181—Paravertebral injection in angina pectoris. The photograph shows points of injection under the lower borders of the upper five ribs and the zone of cutaneous anesthesia. This patient has had complete relief from anginal attacks in the left side of the chest and in the arm for over six years.

cases of angina pectoris or aortic aneurysm, but accurate injection is technically difficult to achieve in about 10 per cent of cases. Furthermore, in a small number of patients the alcohol sets up an irritating neuritis, which may last for a number of weeks. The advantages of injection therapy for the patient who is a poor risk so far outweigh the disadvantages that it is the writer's present routine to use this method for patients with advanced cardioaortic disease. If it fails to give sufficient relief, posterior root section or cordotomy may be undertaken later. For the patient with angina pectoris who is a fair surgical risk, resection of the upper three thoracic sympathetic ganglia is the ideal surgical procedure. In the case of cardiac pain the work of White, Garrey and Atkins<sup>27</sup> has shown that the recently discovered direct thoracic cardiac nerves, which connect the upper thoracic sympathetic ganglia with the heart, account for the frequent failures of the older operation of cervical sympathectomy.

(Fig. 180). When these ganglia or the upper five posterior thoracic spinal roots are destroyed, sensation from the heart is consistently interrupted. In my first case of angina pectoris treated by alcohol injection, complete relief of left-sided pain lasted for over six years (Figs. 181 and 182).

A good understanding of the value of this form of neurosurgical treatment for the relief of intractable pain may be obtained from table 5, which summarizes the cases in which treatment was given at the Massachusetts General Hospital. While the results of sympathetic denervation are most dramatic in the relief of otherwise intractable cases of angina pectoris, this method is proving to be equally valuable in the treatment of numerous other forms of visceral pain seen in idiopathic dysmenorrhea, aneurysm of the aorta, nephralgia, etc., which are listed in table 5. For further details of the applications and technic of sympathectomy for visceral pain the reader is referred to the monograph of White and Smithwick.<sup>9</sup>



Fig 182—Showing the injection of methylene blue in the cadaver. The dye has infiltrated the retropleural tissues around the sympathetic ganglia and their ram.

**Sympathectomy in the Treatment of Disordered Visceromotor Activity.**—Megacolon of neurogenic origin (Hirschsprung's disease), which is often resistant to medical treatment, may be considerably improved

TABLE 5.—NEUROLOGICAL TREATMENT OF INTRACTABLE PAIN

Condition	Operation	No of patients treated	Results*		Complications	Remarks
			Good	Improved	Failures	
Angina pectoris	Resection upper 3 thoracic ganglia	8	8†			Sudden painless death 11 days postoperative, autopsy
	Paravertebral alcohol injection T <sub>1</sub> -T <sub>4</sub>	73	42	18	7	Coronary occlusion Postoperative pneumonia 3 deaths from painless coronary thrombosis,† Alcohol neuritis of intercostal nerves, severe in 6 cases
Painful aortic aneurysm	Paravertebral alcohol injection T <sub>1</sub> -T <sub>2</sub>	3	3			
Carcinoma of the liver	Paravertebral alcohol injection T <sub>6</sub> -T <sub>12</sub>	1	1			Patient has 1 sufficient severely and been hypersensitive to all opium derivatives
Stenosis common bile duct	Right splanchnicectomy	1	1			
Right upper abdominal pain of unknown origin	Resection T <sub>1</sub> -T <sub>9</sub> and major splanchnic nerve	2	2			
Painful spastic colon	Bilateral splanchnicectomy	1	1			
Nephralgia	Resection of nerves in renal pelvis	2	2			
Dysmenorrhea	Resection presacral nerve	20	12	3	4	1 patient not heard from
	Resection presacral nerve plus suspension and D & C	9	7		1	1 patient not heard from

Some of these patients were operated upon by Drs W J Miller, J V Meigs and R. H. Smithwick and are included in this series with the permission of these surgeons.

\*"Good" results include only those patients who obtained from 100 to 90 per cent relief, "improved," from 90 to 40 per cent relief.

†One patient with an excellent early result had a partial recurrence of angina pectoris in the subternal region. It could not be determined whether this was due to removal of only three ganglia or through transmission over nerves on the right side.

‡There have been three other deaths in this series which do not seem to be justly attributable to the procedure. A nonpareil woman of 80 was given injection treatment on account of the unbearable nature of the cardiac pain and died of bronchopneumonia. In an old asthmatic patient, severe bronchial asthma developed three weeks after injection and caused fatal pneumonia. A third patient, a man of 50 with rheumatic fever, aortic regurgitation and the most severe form of anginal attacks, died of progressive cardiac decompensation ten days after an injection, which had relieved his pain.

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## CERVICAL RIB

Cervical ribs (Fig 185) in man are anomalous structures rather than examples of evolutionary reversion Jones attributed the embryological formation of supernumerary ribs to a conflict between forming plexuses and ribs

The snake being without neck waist arms or legs possesses two ribs for each vertebra with corresponding separate segmental nerves In high forms the limb buds cover several vertebral segments the nerves from which grow into the buds The diametric growth of the limb buds however does not keep pace with the longitudinal growth of the vertebral column and segmental nerves soon have to pursue an oblique course to enter the buds Then begins the conflict between the obliquely running nerves and the newly forming ribs The embryonic nerve trunks in the embryo are far larger in proportion to the vertebrae and ribs than in the fully developed animal The obliquely running nerves normally impede the growth of the ribs to the extent that they merely form vertebral processes Todd

the transverse process (2) more advanced the rib reaching beyond the transverse process either with a free end or touching the first rib (3) almost complete the rib connecting with the cartilage of the first rib and (4) complete the rib becoming possessed of a true cartilage that unites with the cartilage of the first rib In several cases I have observed prominent and enlarged transverse processes on the seventh cervical vertebra which produced symptoms similar to those observed in the syndrome of cervical rib

Symptoms—The pain may be sharp and lancinating or it may be a dull ache It usually follows the distribution of the nerves leaving the lower part of the trunk at the brachial plexus but occasionally it may ex-

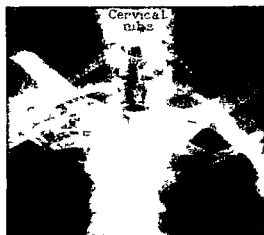


Fig 185—Roentgenographic appearance of cervical ribs

tend upward to the shoulder and into the neck The pain may be more or less continuous and it is invariably exaggerated by rotation of the head or by a forceful downward pull of the shoulder If a patient has been told that he has cervical ribs he will probably complain of vague pains and of general discomfort about the neck and shoulder which can hardly be attributed to the existence of short cervical ribs The patient with cervical ribs that actually produce symptoms usually gives the history of pain following any sudden or violent exertion Housewives usually complain of radiating pain following sweeping washing or dusting One woman complained of pain and numbness along the distribution of the ulnar nerve following difficult labor at childbirth A physician complained of severe pain which was

Vesical distention of neurogenic origin unfortunately is not amenable to treatment by sympathectomy. Dennis Brown<sup>28</sup> and others have shown that there is a crude form of reflex bladder emptying mediated by the intrinsic plexuses of the vesical wall so that the paralyzed bladder can partially empty itself in the absence of its extrinsic nerves. When the innervation of the bladder is intact stretch reflexes are mediated over the sacral parasympathetic fibers and lower centers in the sacral cord. The hypothalamus and premotor cortex exercise an inhibiting control on vesical contraction. The normal act of urination is mediated by parasympathetic fibers derived from the second, third and fourth sacral nerves. The sympathetic fibers which come down through the superior hypogastric plexus carry motor impulses which affect the passage of spermatozoa down the vas deferens and the act of ejaculation but their destruction causes little if any change in vesical function. It can be detected in the cystometrogram. As a result of these recent investigations and the unsatisfactory results following operation the older theory that the function of an overdistended "cord bladder" could be improved by presacral neurectomy has been discredited.

In this short review of surgery of the autonomic nervous system no attempt has been made to discuss the treatment of diseases in which recent experience has found sympathectomy to be of little practical value. These include exophthalmic goiter, epilepsy, and spastic paralysis. It is interesting, however

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by interrupting the sympathetic fibers to the colon and rectum (Fig 183) Children with megacolon should be tested with a barium enema which cannot be evacuated spontaneously (Fig 184 a) After spinal anesthesia

favorable group oral medication with acetyl beta methylcholine bromide (mecholyl bromide) with such simple aids as liquid petrolatum and an occasional enema is sufficient to relieve the condition Occasionally

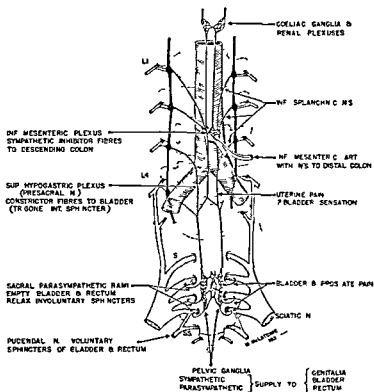


FIG 183—The nerve supply of the pelvic viscera

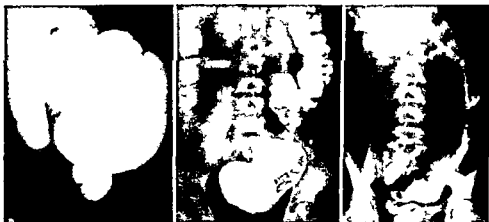


Fig 184—Megacolon (Hirschsprung's disease) treated by resection of the sympathetic and lateral nerves. a Barium filled colon after unsuccessful effort to evacuate the enema. b Active peristalsis and successful evacuation after spinal anesthesia. c Effective emptying of colon and rectum after operation.

the colon should show active peristalsis and an ability to empty itself. At times the improvement in defecation which follows a single or repeated spinal blocks is sufficient to restore normal bowel movement. In the more

sympathetic denervation of the colon is necessary and is best carried out by bilateral resection of the lumbar sympathetic chain.

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Vesical distention of neurogenic origin unfortunately is not amenable to treatment by sympathectomy. Denny-Brown<sup>24</sup> and others have shown that there is a crude form of reflex bladder emptying mediated by the intrinsic plexuses of the vesical wall, so that the paralyzed bladder can partially empty itself in the absence of its extrinsic nerves. When the innervation of the bladder is intact, stretch reflexes are mediated over the sacral parasympathetic fibers and lower centers in the sacral cord. The hypothalamus and premotor cortex exercise an inhibiting control on vesical contraction. The normal act of urination is mediated by parasympathetic fibers derived from the second, third and fourth sacral nerves. The sympathetic fibers, which come down through the superior hypogastric plexus, carry motor impulses which affect the passage of spermatozoa down the vasa deferentia and the act of ejaculation, but their destruction causes little, if any, change in vesical function that can be detected in the cystometrogram. As a result of these recent investigations and the unsatisfactory results following operation, the older theory that the function of an overdistended "cord bladder" could be improved by presacral neurectomy has been discredited.

In this short review of surgery of the autonomic nervous system, no attempt has been made to discuss the treatment of diseases in which recent experience has found sympathectomy to be of little practical value. These include exophthalmic goiter, epilepsy, and spastic paralysis. It is interesting, however, to recall that cervical and lumbar ramisection, proposed by Royle and Hunter for the reduction of muscle tone, although not generally accepted for the treatment of this particular condition, led directly to the present operations for Raynaud's disease and megacolon. With the possible exception of the much discussed subject of hypertension, experience with sympathetic neurosurgery in the conditions taken up in this chapter has now reached a point where the effects of these operations are well known and their therapeutic value in properly selected cases is thoroughly established.

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## CERVICAL RIB

Cervical ribs (Fig 185) in man are anomalous structures rather than examples of evolutionary reversion Jones attributed the embryological formation of supernumerary ribs to a conflict between forming plexuses and ribs

The snake being without neck waist arms or legs possesses two ribs for each vertebra with corresponding separate segmental nerves In high forms the limb bud is over several vertebral segments the nerves from which grow into the buds The lametric growth of the limb buds however does not keep pace with the longitudinal growth of the vertebral column and segmental nerves soon have to pursue an oblique course to enter the buds Then begins the conflict between the obliquely running nerves and the newly forming ribs The embryonic nerve trunks in the embryo are far larger in proportion to the vertebrae and ribs than in the fully developed animal The obliquely running nerves normally impede the growth of the ribs to the extent that they merely form vertebral processes Todd stated that in the fetus, ribs are normally present in articulation with vertebrae above the eighth and that after birth they are present only as transverse processes of the cervical vertebrae

Gruber divided cervical ribs into four groups according to the extent of growth (1) slight degree the rib reaching beyond

the transverse process (2) more advanced the rib reaching beyond the transverse process either with a free end or touching the first rib (3) almost complete the rib connecting with the cartilage of the first rib and (4) complete the rib becoming possessed of a true cartilage that unites with the cartilage of the first rib In several cases I have observed prominent and enlarged transverse processes on the seventh cervical vertebra which produced symptoms similar to those observed in the syndrome of cervical rib

Symptoms—The pain may be sharp and lancinating or it may be a dull ache It usually follows the distribution of the nerves leaving the lower part of the trunk at the brachial plexus but occasionally it may ex-

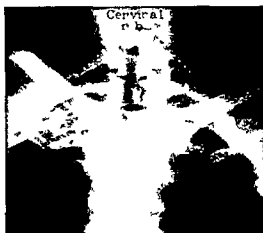


Fig 185—Roentgenographic appearance of cervical ribs

tend upward to the shoulder and into the neck The pain may be more or less continuous and it is invariably exaggerated by rotation of the head or by a forceful downward pull of the shoulder If a patient has been told that he has cervical ribs he will probably complain of vague pains and of general discomfort about the neck and shoulder which can hardly be attributed to the existence of short cervical ribs The patient with cervical ribs that actually produce symptoms usually gives the history of pain following any sudden or violent exertion Howelives usually complain of radiating pain following sweeping washing or dusting One woman complained of pain and numbness along the distribution of the ulnar nerve following difficult labor at childbirth Aglives were complained of severe pain which was

projected along the median and ulnar nerves after struggling with an insane patient who attempted to commit suicide. Hyperesthesia, paresthesia and anesthesia may be associated with the pains and may persist after strenuous exertion. Decreased reflexes and loss of motor power do occur when the symptoms are pronounced and of long duration. Patients with mild symptoms do not require operation unless the blood pressure and radial pulse can be reduced or stopped by elevation of the chin and rotation of the head to the affected side on inspiration. Atrophy occurs late and is rarely complete.

In 1905 Thorburn reported 2 cases of atrophy of the intrinsic muscles of the hand associated with cervical rib. Jones in a series of 14 cases of atrophy of the intrinsic muscles of the hand on roentgenologic examination found cervical ribs present in 10. Wilson found atrophy to be of two types, the median or partial ulnar type and the ulnar type. In the former there is paralysis of the abductor pollicis muscle and the opponens pollicis muscle which are supplied from the sixth and seventh cervical nerves; the remaining ulnar muscles are intact. The flexor pollicis brevis is also supplied by the median nerve but probably from a different segment. The ulnar type *man en griffe* in which there may be paralysis of all the muscles of the hand except the two innervated by the median nerve is the result of injury of the eighth cervical nerve.

Circulatory symptoms are rarely severe. One arm or hand sometimes becomes more deeply cyanotic than the opposite upper extremity, with mild trophic changes in the tips of the fingers. Several cases have been reported however in which gangrene of one or more fingers occurred. In this event obiteration of either the radial or the ulnar artery or of both also usually occurs. Diminution in the volume of the radial pulse is frequently observed on the affected side. This phenomenon can be accentuated by instructing the patient who has cervical rib to sit upright on the examining table with the arms relaxed to take a full breath to elevate the chin and then to rotate the head to the affected side. The diminution in the radial pulse is due to compression of the subclavian artery between the scalenus anticus muscle and the brachial plexus which has been displaced forward by the supernumerary rib. Unless the symptom is associated with other complaints little or no relief will be obtained by removal of the cervical rib or section of the scalenus anticus muscle.

The presence of Horner's syndrome has been attributed to traction on the stellate sympathetic ganglion. In one of the cases in the writer's series the patient complained of a reflex cough every ten or fifteen seconds; this was relieved by sectioning an anomalous twig from the phrenic nerve which had been caught in the scar tissue where the scalenus anticus muscle compressed the subclavian artery. The brachial symptoms were relieved by tenotomy of the scalenus anticus muscle.

**Surgical Considerations.**—In a review of cases observed at the Mayo Clinic it was learned that the incidence of cervical ribs was 0.056 per cent. Of 303 patients with cervical ribs 84 were males and 219 females. Roentgenographic examination revealed bilateral cervical ribs in 143 cases, a unilateral rib on the right in 70 and a unilateral rib on the left in 90, a supernumerary cervical tubercle was invariably present on the opposite side in all cases of unilateral cervical rib. In 167 cases (55 per cent) the presence of cervical ribs was discovered accidentally by means of roentgenograms as there were no symptoms. In 81 cases the roentgenograms were positive but since the symptoms were mild and indefinite in character operation was not advised. In 57 cases the symptoms justified surgical treatment.

The older surgical procedures consisted of resecting supernumerary ribs by the lateral or posterior approach. The writer followed this method until he had occasion to explore through the supraclavicular triangle the subclavian artery of a patient with cervical ribs who complained of the classic syndrome and who had gangrene of two fingertips. He then observed that removal of the rib only partially relieved the pressure and it was not until the tendinous insertion of the scalenus anticus muscle was divided at the first rib that all constriction about the subclavian artery and the brachial plexus was relieved (Fig. 186).

Prior to 1925 23 patients had been operated on by the transcervical or posterior approach for the removal of cervical ribs. Since then the writer has operated on 10 patients through the anterior cervical approach at which time the tendinous insertion of the scalenus anticus muscle was divided in conjunction with removal of the

**cervical rib** The anterior cervical approach has continued in use but division of the tendinous insertion of the scalenus anticus muscle is the only procedure employed. This same surgical procedure is employed for the relief of the *scalenus anticus syndrome*, a group of symptoms simulating those produced by a cervical rib. However, they have arisen from an enlarged transverse process on the seventh cervical vertebra and narrowing of the space between the process and the posterior border of the scalenus anticus muscle. In comparing the

arterial occlusion have developed. In 2 cases cervicothoracic sympathetic ganglionectomy was performed subsequently to relieve vasospastic phenomena. There has been only 1 death in the series and that was of a patient who had gangrene of the index and middle fingers, thrombosis of the radial artery and a large elbow-like atheromatous change of the subclavian artery under the scalenus anticus muscle. This patient's immediate convalescence was uneventful but on the twentieth postoperative day the calcareous plaque gave way and the patient

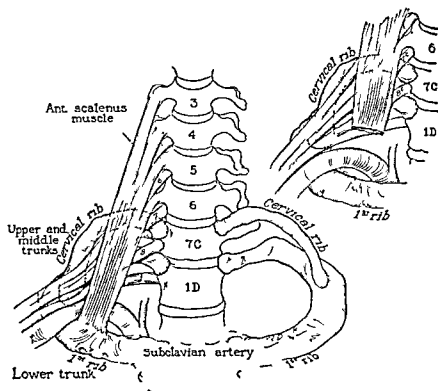


Fig. 186.—Diagrammatic representation of compression of the subclavian artery and brachial plexus between the cervical rib and the scalenus anticus muscle and of the relief of compression on section of the muscle at its insertion.

results of the various operations it was observed that this newer procedure was more effective than mere removal of the cervical rib and that the results were equally as good as the results obtained when the rib was removed in conjunction with division of the tendinous insertion. Radiating pain and paresthesia are quickly relieved by the operation unless there is marked evidence of irritation of the nerve root and atrophy of muscles. The circulatory phenomena improve and disappear unless permanent changes such as atheromatous patches and

died from hemorrhage before the subclavian artery could be ligated proximal to the point of rupture.

**Surgical Technique.**—An oblique incision is made for a distance of about 5 cm. extending upward and backward from the sternoclavicular articulation into the posterior triangle. The incision is carried through the platysma myodes muscle and fat until the tendon of the sternocleidomastoid muscle with its attachment to the clavicle is exposed. The clavicular attachment is divided between two forceps. The muscle portion is then reflected medially, exposing the tendon of the omohyoid and the tendinous attachment of the scalenus anticus muscle with the phrenic nerve running

obliquely across it from the lateral to the mesial border. During dissection the transverse cervical and the suprascapular arteries are divided and ligated. The scalenus anticus muscle is dissected free and the phrenic nerve is retracted mesially before the tendinous and muscular insertion is divided. The subclavian artery will appear on the lateral side of the scalenus anticus muscle and if the space between the cervical rib (or the cervical rib and the tendinous fans to the thoracic rib) and the lateral border of the scalenus anticus muscle is narrow one immediately observes compression of the subclavian artery against the trunk of the brachial plexus. On the mesial side of the scalenus anticus muscle one may observe the pleura and if dissection is carried still farther mesially the carotid sheath and the vertebral artery will be exposed this however is unnecessary.

It is important to carry the dissection upward on the anterior surface of the scalenus anticus muscle for a distance of 5 cm in order to expose the phrenic nerve thoroughly before retracting it medially. One must bear in mind before dividing the scalenus anticus muscle at its insertion that it lies over the compressed portion of the subclavian artery and that the pleura is situated mesially to the inner border of the muscle in order to avoid injury to both structures. Section of the musculotendinous insertion is most easily accomplished by dividing the fibers in small groups with scissors. The cut fibers promptly retract upward thus exposing the undivided fibers and the compression of the artery. As soon as the scalenus anticus muscle has been divided the subclavian artery will be seen to slide forward and take on its normal caliber and the lower trunk of the brachial plexus will likewise slide forward and downward to be free in the supraclavicular triangle.

The wound is closed in much the same manner as any operative wound. The scalenus anticus muscle retracts upward. If division of the omohyoid tendon has been necessary it should be reunited by suture before the clavicular portion of the sternocleidomastoid muscle is resutured with mattress sutures of chromic catgut. The patient may be permitted to sit up on the day following operation. He may be dismissed from the hospital in three days and from the surgeon's care as soon as the wound in the skin has healed.

Comparing the technique of the anterior approach and division of the scalenus anticus muscle with the lateral approach and retraction of the brachial plexus necessitates to expose and resect the cervical rib one appreciates very readily the difference between the two methods to say nothing of the relative effectiveness of the two procedures. The former can be carried out with ease and without danger of traumatizing the brachial plexus whereas the latter requires considerable dissection and retraction of the brachial plexus.

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#### BIRTH PALSIES

The term birth palsy should be confined to cases in which the evidence justifies the assumption that the fetus was intact at the beginning of labor and was damaged by some one of the various stresses incident to delivery.

The difficulties in diagnosis are formidable partly because of the obvious fact that stresses and their effects are so difficult to appraise and partly because it is so hard to discuss "birth injury," "obstetrical accident" and so on without some implication of obstetrical mismanagement. Obviously very little progress will be made if the diagnosis is involved with a controversy of this sort.

The reasonable attitude is to start with the idea that the process of labor involves severe stress on the nervous system of the child and that the obstetrician fulfils his duty when he does his best to control all the various forces. The occurrence of injury, whether from rupture of tissue, edema, asphyxia or anoxemia, implies that the obstetrician was not able to prevent an imposition of stresses which were beyond the child's limit of tolerance, but it most emphatically does not indicate any ignorance or lack of skill on the part of the obstetrician.

With this understanding it is profitable to attempt to understand the forces which affect the nervous system of the child.

The brain the spinal cord or the peripheral nerves can be injured. In a brief review it is impossible to consider the various controversial matters but in general the discussion can be separated into three divisions.

**Cerebral Palsies—Definition**—Any motor disturbance due to injury of the brain is a result of parturition. In general certain postnatal conditions such as bleeding due to hemorrhagic disease of the newborn are usually included since a differential diagnosis is essentially impossible.

**Etiology**—1 Rupture of tissue particularly rupture of the intracranial septa with consequent disturbances of pressure relations and bleeding from the veins and sinuses which are enclosed between the layers.

2 Edema due to prolonged or excessive pressure particularly when early rupture of the amniotic membranes leads to gross differences in pressure on the part of the head occupying the os uteri and the rest of the fetus.

3 Intracerebral or intraventricular hemorrhage without rupture of the dural septa.

4 Hemorrhage due to constitutional causes or to asphyxia as such.

5 Anoxemia due to occlusion of the placental circulation by strangulation of the cord or premature separation of the placenta.

On the whole the mechanical factors are most readily understood and are most easily studied from a prophylactic standpoint. In general premature infants are peculiarly liable to intracranial hemorrhage regardless of the method of delivery. Obviously dystocia increases the liability to injury and without question in a very large proportion of breech deliveries the infant suffers from trauma. Forceps used skillfully and with restraint probably play a less important part than is usually stated.

**Diagnosis** in the period immediately after birth depends on two things. First on evidence that no prenatal lesion can account for the condition second on evidence that the brain is not functioning in an adequate manner. Prolonged apnea after birth recurrent cyanosis refusal to nurse or convulsions are the usual symptoms. On examination changes in the reflexes bulging of the fon-

tanelle and apathy or irritability with irregular respiration are frequent.

Lumbar puncture frequently reveals important evidence but neither a high cerebral spinal fluid pressure nor blood in the fluid is pathognomonic. Direct puncture through the suture line below the angle of the fontanelle is often advisable in order to establish the presence of subdural or ventricular bleeding.

Later in infancy or in childhood the diagnosis is less certain and is made by establishing the presence of a cerebral lesion and reviewing the history of the labor and of the neonatal period. Encephalography is often of great value. Also it is obvious enough that any cerebral injury severe enough to produce motor signs may involve sensory and mental mechanisms. Any appraisal therefore should include a careful study of the effect of the supposed lesion on the intellect of the child.

**Prophylaxis** depends on the obstetrician and on his ability to modify the stresses on the fetus.

**Surgical treatment** in the immediate postnatal period is concerned largely with the control of hemorrhage and with the control of intracranial pressure. Transfusion after suitable study of the blood and injection of whole blood are the methods of control of hemorrhage. The role of vitamin K is still somewhat confused. Undoubtedly hemorrhagic disease of the newborn can be largely prevented but it is doubtful whether vitamin K is useful in the treatment of established intracranial hemorrhage. The best summary was presented in a round table discussion published in the *Journal of Pediatrics* in 1949. Rigid attention to quiet practically like that given premature babies is needed. Probably more injured babies die from too much manipulation and exposure than from too little surgical intervention. In some cases repeated punctures or even direct surgical attack on a subdural hematoma is worth trying. In recent years the subject has received increasing attention and a paper by Ingraham and Matson summarize the present situation adequately.

Later on the advisability of palliative surgical treatment depends on a careful and conservative appraisal of the remaining physiologic assets. Operations of any kind

ire of course futile in the presence of gross feeble-mindedness and should be reluctantly undertaken unless there is clear evidence that reasonable intelligence exists

The confusion about types of operation would be enormously diminished if a careful psychologic and physiologic appraisal preceded discussion of indications

**Spinal Birth Palsies**—The care in the writer's experience always the result of direct force imposed on the child by the obstetrician Usually they result from breech extraction As far as I know they are never helped by direct surgical attack on the lesion itself Later treatment depends on the degree of damage which varies from almost complete disintegration of the whole lower cord to trifling damage to the anterior horn cells

**Birth Palsies of the Brachial Plexus**—Palsies of this sort are relatively common The essential mechanism in most cases is lateral traction on the head against a shoulder which is still within the birth canal The injury is frequently confined to the upper roots of the plexus but may involve the whole plexus and the sympathetic fibers connected with it

*Surgical exploration* of the plexus is legitimate but it is wise to postpone it until it is clear that recovery without operation is unlikely While waiting a period of from several months to a year the prevention of contractures is essential Carefully planned splints usually ones which maintain the arm in abduction and external rotation or carefully supervised physiotherapeutic routines or combinations of the two are necessary In later cases in which deformity occurs as a result of contractures and bony changes in the shoulder joint corrective operations of the type suggested by Sever are of great value

BROXSON CROTHERS

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## SPINA BIFIDA AND CRANIUM BIFIDUM

(*Meningocele Myelomeningocele Encephalomeningocele*)

**Definition**—Hernial protrusion of the meninges through vertebral or cranial defects occurs in infants as a congenital abnormality The hernial sac contains cerebrospinal fluid and often nervous tissue is present free in the sac or attached to its walls

**Types of Spina Bifida and Cranium Bifidum**—A large number of classifications have been proposed hence the complexity of nomenclature is confusing From the surgical standpoint the following simplification and alteration of the classification used long ago by von Recklinghausen is practical

*Spina Bifida with Meningocele*—Meningocele is associated with a local unfinished closure of the vertebral arch or arches The overlying skin may be normal or covered by a thin parchment like epithelium The sac is composed of the meninges and contains only spinal fluid

*Spina Bifida with Myelomeningocele*—Nerve roots or the spinal cord may be present in the sac or attached to its walls In myelomeningocele there are many different degrees of involvement of the spinal cord but it seems unnecessary to marshal the bewildering number of names which have been applied to the various forms of these anomalies

*Rachischisis* is a term used arbitrarily in this instance to designate the more extreme abnormalities encountered in cases of spina bifida The bony defect is wide because of the absence of laminae and pedicles and nervous tissue is directly exposed There is little or no sac formation The defect is both *myeloblastic* and *epiblastic*

*Spina Bifida Occulta Posterior (or Anterior) with Meningocele*—The overlying skin is normal in appearance except for frequent hypertrichosis or a lipomatous mass beneath it The defect is usually posterior but sometimes protrusions take place through a defect in the vertebral bodies and the sac projects into the abdominal cavity or the thorax

*Spina Bifida Occulta Posterior (or Anterior) with Myelomeningocele*

**Cranium Bifidum with Meningocele**—These hernial protrusions occur almost invariably at the midline. They are usually dorsal and are found most commonly in the occipital region but sometimes are ventral, extending into the mouth.

**Cranium Bifidum with Encephalomeningocele**—As in myelomeningoceles the amount of nervous tissue in the sac is variable.

**Cranioschisis**—As in rachischisis the nervous tissue is exposed and there is little or no sac.

are to be seen in great numbers throughout the tissue. There are usually many irregular clumps of cells with large nuclei. These cellular clumps which are often in intimate contact with the blood vessels resemble closely the arachnoidal cell nests with which one is familiar in the fully developed arachnoid. Such clumps often connect the fluid spaces within the tissue with vessels, thus resembling the arachnoidal collections in the pachionian granulations or arachnoid villi. There are also other similarities. In sacs removed from adult patients numerous psammoma bodies have been identified and chromatophore cells identical in appearance with those seen normally in the leptomeninges have been encountered. Finally it has been demonstrated that the tissue spaces in the sac communicate with the subarachnoid space. If lampblack is injected into the

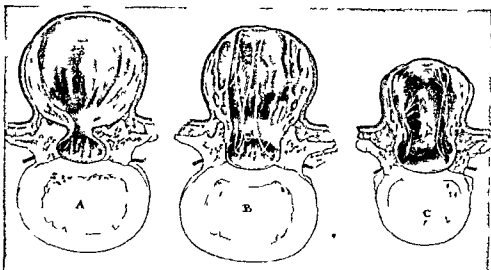


Fig. 187—Schematic horizontal section illustrating cases of spina bifida. A, Sacral meningocele; B, sacral myelomeningocele; C, high lumbar myelomeningocele. Note that the sac is continuous with the dura mater and is separable from the skin.

**The Meningocele, Myelomeningocele and Encephalomeningocele Sacs**—In the meningocele, myelomeningocele and encephalomeningocele there is a fluid-containing sac beneath the skin or its parchment-like continuation. The dural and arachnoidal membranes are usually inseparable at the mouth of the cranial or spinal defect, and the sac is an outward continuation of this undifferentiated meninx (Fig. 187). Nerve roots or the spinal cord itself may be attached to or incorporated in the sac in spina bifida, and there may be similar attachments in cranium bifidum in the encephalomeningocele. The meningocele sac is always separable from the skin, though separation is difficult when the skin covering is thin and parchment-like.

Histologically the sac is composed of loose collagenous tissue resembling arachnoid. Thin-walled veins

cisterna magna soon after death the spaces in the sac are filled with it and the ink stops abruptly at the point where sac tissue passes over into the surrounding connective tissue.

Therefore it is evident that there is a cellular differentiation within the sac of meningoceles *et al.* which strikingly resembles the arachnoidal membrane and that the arachnoidal cell clusters bear the same relationship to blood vessels and cerebrospinal fluid spaces in the sac as they do in arachnoid villi and pachionian granulations. From the histologic evidence it would seem that there is absorption of cerebrospinal fluid into the blood stream within the sac.

**Embryological Considerations—General**—In the normal human fetus the entire neural tube closes at about the end of the third week of intrauterine life. Mesoblastic tissue grows between the surface ectoderm and the neuroectoderm and from this tissue develop the membranes which are to enclose the central nervous system, the vertebrae and the skull. At about the eleventh week the vertebral canal from the first cervical to the third or fourth sacral vertebra is covered over by the union of the laminae. The spinal cord and vertebral column are of equal length until the twelfth

week. As the fetus grows the vertebral canal becomes proportionately longer until the conus is left at the level of the twelfth thoracic or first lumbar vertebra in adult man. It is obvious therefore that developmental anomalies on which these abnormalities are based make their appearance at an early embryological period. If nerve roots or the spinal cord are involved the upward migration of the cord is prevented. This is a factor which must be considered when symptoms develop later in life in patients with spina bifida but which is of no significance in the problems presented by cranium bifidum.

*The Experimental Production of Spina Bifida and Anencephaly*—One of the most conclusive chapters in experimental teratology is the subject of spina bifida. Hertwig in 1892 described the development of spina bifida in frog embryos which he thought was due to polyspermy. He was able to produce the anomaly only occasionally by his experimental method. Nevertheless drawing from von Recklinghausen's exhaustive article on human spina bifida, Hertwig pointed out that his own experimental findings might indicate the true mechanism by which spina bifida is produced. In 1902 Morgan and Tsuda found that if frogs' eggs were placed in a 0.6 per cent solution of sodium chloride the blastophore did not close and spina bifida resulted regularly, producing also some specimens showing typical anencephaly. With this more reliable experimental method Hertwig continued his studies and extended the observations to other species. As a result of his work Hertwig finally questions whether it is not possible for chemical substances in the blood to pass from the human uterus to the ovum in order to produce these abnormalities. He concluded that these abnormalities could be produced in any embryo by altering its normal environment. The fact that malformations occur in embryos artificially incubated has long been recognized by embryologists.

*Etiology of Spina Bifida Suggested by the Study of Pathologic Human Embryos*—Mall collected many human embryos and encountered various types of cranium bifidum and spina bifida among them. He was able to demonstrate pathologic changes in the chorion in most of the embryos showing abnormality. This was usually the result of an endometritis which prevented proper implantation. The embryos from tubal pregnancies showed a much higher percentage of malformations than those from the uterus. Mall emphasized to bring out the significance of faulty implantation. His specimens showed not only an arrest of development but also tissue destruction and scar formation. At the stage of closure of the neural tube the nervous tissue is very sensitive and the period is a critical one. Mall showed that when the effect of faulty implantation is operative at this time the deformity results and that if the embryo is to continue to grow the placental abnormality must correct itself.

Mall concluded as had Hertwig that spina bifida and cranium bifidum are due to the action of external influences on the egg after fertilization. The principal significance of the observations made from experimental embryology and from aborted human embryos is their bearing on the question as to whether the defects are inherited or acquired. These observations favor the viewpoint that they are acquired. If Mall's conclusions

are accepted then any woman who has had a pathologic embryo or a congenitally abnormal child should undergo gynecological examination and perhaps curettage before subsequent pregnancies are permitted.

*The Cerebrospinal Fluid and Spina Bifida and Cranium Bifidum*—The developmental anomalies in the neural tube leading to spina bifida and cranium bifidum take place long before cerebrospinal fluid is formed. Weed's embryological studies have proved that cerebrospinal fluid is formed from the choroid plexuses and from his work it is obvious that they develop and begin to function at a stage later than any which can affect the closure of the neural tube. He showed that with the passage of cerebrospinal fluid out of the ventricle into the undifferentiated perimedullary mesenchyme spaces develop and the subarachnoid space is formed. The first passage of fluid out of the ventricle takes place normally through the roof of the fourth ventricle, and the first arachnoid differentiation takes place in the adjacent mesenchyme at this level. Weed also demonstrated that the absorption of cerebrospinal fluid takes place through arachnoid villi, i. e. arachnoid cell nests which project into veins.

It seems justifiable to conclude that defects of the neural tube leading to spina bifida and cranium bifidum permit the early passage of ventricular fluid into the perimedullary mesenchyme at the level of the defect, which causes the early differentiation of the arachnoid at this level. There are formed not only spaces but arachnoid villi. It is our belief that arachnoid tissue of the meningeal sac provides for so much absorption of cerebrospinal fluid that there may be no necessity for the normal subarachnoid system to develop when a meningeal sac is present.

This hypothesis is strengthened by clinical evidence. When it was a customary surgical procedure to amputate meningeal sacs, hydrocephalus frequently developed after operation. Cutler concluded that "while modern surgery has made amputation of the sac safe from meningitis it may be justly accused of causing death by hydrocephalus." He concluded as had others that there was clinical evidence that the sac was a safety valve for excessive cerebrospinal fluid but he failed to recognize the true functional significance of the sac. It was Penfield who first realized that the sac is an absorbing mechanism and that removal causes hydrocephalus because absorption of cerebrospinal fluid cannot keep pace with its formation when the absorbing tissues are taken away. Since operations have been carried out in which the meningeal sacs are dissected out and all the arachnoid tissue is preserved, hydrocephalus has not developed postoperatively.

*Associated Anomalies*—Multiple congenital anomalies associated but unrelated are sometimes encountered in the central nervous system with spina bifida and cranium bifidum. Two varieties of spina bifida may be present in the same case (Fig. 191 b). The writer has also encountered a simple meningocele with cranium bifidum and a sacral type of spina bifida in the same infant.

Hydrocephalus (Fig. 189, b) is a commonly associated congenital abnormality. Hardlip congenitally displaced hips, non-paralytic clubfoot (Fig. 189, a) and other abnormalities are also commonly associated owing



perhaps to the same etiological factor but otherwise unrelated

One of the important anomalies in spina bifida with myelomeningocele from the clinical standpoint is that related to the development of the protrusion with its enclosed nervous tissue. In myelomeningocele the spinal cord is fixed and cannot migrate upward during the disproportionate increase in the growth of the vertebral canal. Keiller's schematic drawings (Fig 189) illustrate the anomaly which results. This point deserves emphasis because the relationship of the cord to its surroundings is maintained as an embryonic relationship is present at the time of the origin of the defect. Traction on the attached cord may therefore be a factor in the etiology of symptoms occurring in later life (childhood, adolescence or adult life).

**Types of Lesion**—Keiller found reports in the literature of 170 cases of spina bifida in which she considered the anatomical data were accurate enough to permit of classification. After the cases were grouped to fit the classification which she proposed the percentages obtained were as follows: 41 per cent spina bifida occulta with symptoms, 2.3 per cent meningoceles with adherent crura equina, 70.6 per cent myelomeningoceles, 1.7 per cent syringomyelomeningoceles and 21.1 per cent simple meningoceles. The cases of simple meningoceles were the only ones in the series which did not present secondary nervous lesions, thus indicating that in 78 per cent of the cases there was involvement of the cord or its nerve roots to some extent.

It is unfortunate for statistical purposes that a standard classification of types has not been accepted.

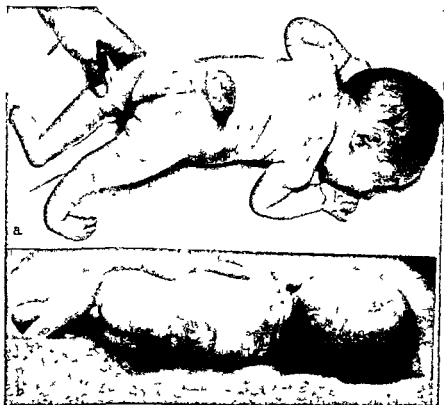


Fig 189—Meningoceles with associated malformations: *a*, Lumbar spina bifida with myelomeningocele and non-paralytic clubfeet; *b*, lumbosacral spina bifida with myelomeningocele and hydrocephalus.

**Statistics—Frequency**—Statistics are difficult to collect on the incidence of cranium bifidum. Spina bifida with protrusion is said to occur once in one thousand births, and in most large series of deliveries these figures are approximated. Keiller points out that the cases of spina bifida occulta not discoverable at birth are omitted in these figures.

**Location**—Moore's collected series of 385 cases treated by excision of the sac is one of the largest series reported from which statistics as to location are available. Since the patients were suitable for operation his series of course represents an already selected group of cases. Of the 385 cases 23 per cent were sacral, 34 per cent lumbar, 29 per cent lumbosacral, 4.5 per cent thoracic, 9.5 per cent cervical. There were two patients with occipital meningoceles.

**Symptoms and Signs**—The presenting symptom in cranium bifidum with meningocele and encephalomeningocele is a protruding hernial sac situated in the midline of the skull. The protrusions are encountered at almost any point, though they are rarely related to the fontanelles. When the sac projects through the base, the nasopharynx may be obstructed, and there is usually an associated anomaly in the superior maxilla with cleft palate and sometimes harelip. Figure 190 shows some of the locations in which cranium bifidum with protrusion occurs.

In spina bifida with meningocele or myelomeningocele the protrusion is also in the midline and may be encountered at any level of the vertebral canal (Fig. 181). Only the occult variety offers any difficulty in immediate diagnosis.

The occult cases are relatively infrequent and do not require emergency treatment. The surgical problem presented is chiefly

that of the overlying skin and the size of the bony defect through which they occur. Often the surface epithelium is irregularly lacking at birth, and cerebrospinal fluid percolates through the spongy tissue of the sac, keeping the surface moist. Again, the surface ectodermal covering may be complete, but the sac is so thin as to require the greatest caution during examination and nursing care

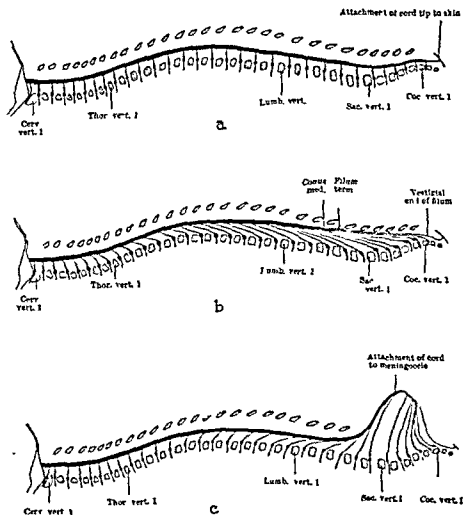


Fig 189—Diagrammatic representation of the migration of the spinal cord and the relations of the nerve roots *a*, in a three months' fetus, *b*, in a fetus at term, *c*, in myelomeningocele. The skeletal basis of all the figures was taken from the dissection of the spinal column of a seven months' fetus (Keiller)

one of fixation of the cord leading to traction on nerve roots and is different from that presented by spina bifida with posterior protrusion. In cases showing the rachischitic or cranioschitic type of anomaly with the spinal cord or brain exposed and little or no sac present, surgical treatment can accomplish little.

*Examination of the Protrusion*—(a) The protrusions vary greatly as to size, the char-

acter of the overlying skin and the size of the bony defect through which they occur. Often the surface epithelium is irregularly lacking at birth, and cerebrospinal fluid percolates through the spongy tissue of the sac, keeping the surface moist. Again, the surface ectodermal covering may be complete, but the sac is so thin as to require the greatest caution during examination and nursing care

(b) Transillumination of the protrusion in a dark room provides a simple procedure which aids in differentiating between the meningoceles containing only fluid and those containing nerve tissue. The projecting cere-

bral tissue can be outlined in cases of cranial defects and the nerve roots of the spinal cord itself can be identified running up to the sac in cases of spina bifida.

(c) Oxygen injected into the sac makes a ray visualization of the contents of the sac possible and also the outlines of the bony defect are clearly seen. Unfavorable reactions do not follow the use of this diagnostic procedure if suitable precautions are taken. The infant's head should be kept low in spina bifida and high in cranium bifidum. A long needle is inserted through normal skin

(d) Aspiration of the fluid from the sac and palpation when it is collapsed will give information as to the contents of the sac and the size of the bony defect. The same precautions that have been outlined to prevent subsequent leakage of cerebrospinal fluid are necessary. In addition to this and in order to minimize the effect of the sudden reduction of pressure in this diagnostic procedure the head should be kept low during and for a considerable period after the removal of fluid in cases in which the protrusion is below the level of the fourth ventricle.

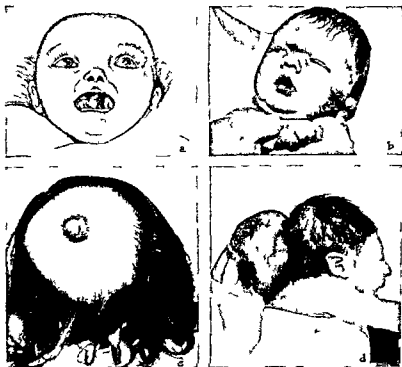


Fig 190—Location of meningoceles. *a* Into the mouth through a cranium bifidum at the base of the skull. *b* frontal cranium bifidum with meningocele. *c* posterior parietal cranium bifidum with small meningocele. *d* occipital cranium bifidum with encephalomeningocele. The nervous tissue was connected with both cerebral hemispheres.

at a considerable distance from the sac this prevents subsequent leakage of fluid. Fluid is removed in small amounts and replaced with like amounts of oxygen; the exchange being carried out until no more fluid can be removed. Plates are taken with the infant's head lower than the defect in cases of spinal defects with the head up in cases of cranial defects. Additional information may later be obtained by roentgenograms of the rest of the central nervous system if the position is gently altered so that oxygen may pass slowly from the sac to the subarachnoid space and the ventricles.

and conversely kept elevated when it is above this level.

(e) Electrical stimulation with weak faradic current in cases of spinal defects provides a further method of determining whether or not nerve roots or spinal cord tissue is present in the sac. As the electrode is drawn over the sac isolated motor responses will result as nerve roots are crossed and grouped muscle responses will be observed when the spinal cord is stimulated. Very young infants do not seem to resent this procedure and in older infants it seems to cause no more discomfort than the usual

sensory examination. In no instance in our experience have responses been observed following stimulation of the encephalomeningoceles

(f) Examination of the sac for ballottement by the application of sudden pressure over the fontanelle may give some indication of the freedom with which the sac communicates with the ventricular system and the subarachnoid space. An impulse can frequently be felt over the fontanelle when sudden pressure is made over the sac further indicating the freedom of communication.

Rachischisis and cranioschisis have not been considered with the foregoing because

the degree of involvement of the central nervous system, the direct result of the disease. Grave associated anomalies are usually fairly obvious and are not difficult to recognize. Incipient or early hydrocephalus is suggested by large fontanelles and open suture lines even before enlargement of the head has begun and the typical signs have developed.

Reflex and other motor activities in newborn infants differ from those of the adult. In a careful study Chaney and McGraw point out the responses to be expected in apparently normal infants immediately after birth and during the period they are kept in the maternity nursery. By a systematic ex-

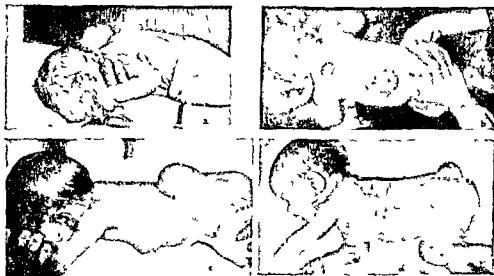


Fig 191—*a*, Cervical spina bifida with meningocele, *b*, dorsal spina bifida with simple meningocele and lumbar spina bifida with myelomeningocele, *c*, lumbar spina bifida with myelomeningocele, *d*, sacral spina bifida with meningocele

they present little or no sac and nervous tissue is exposed. Because these deformities are routinely associated with other anomalies in the central nervous system, no surgical intervention is justifiable. Cases of cranioschisis have been reported in which the exposed brain has been stimulated electrically, and responses have been observed. In rachischisis, stimulations of the exposed cord by the lightest touch with cotton wool or with weak electrical currents often produce motor movements, showing that even this tissue, almost unrecognizable as spinal cord tissue, is capable of producing reactions.

**General Examination.**—A searching examination is carried out to determine the possible presence of other anomalies and

amination along the lines they indicate, information as to the presence of other associated defects of the central nervous system, as well as those secondary to the lesion, can be obtained.

**Treatment.**—*Surgical Treatment.*—For the last eleven years we have preserved the meningocele sac at operation in all cases of spina bifida and cranium bifidum with protrusion because of its absorbing function. Figures 192, 193 and 194 illustrate the steps in the surgical procedures in these conditions.

Under light ether anesthesia the infant is placed in the prone position with the meningocele uppermost and the body on a plane to minimize the escape of cerebrospinal fluid

After being shaved the skin is washed well with soap and water and sterilized with a 7 per cent solution of iodine left in place for three minutes before removal with alcohol. When ulcerated areas are present they are kept covered with dressings sutured to the skin.

from the sac until the neck of the sac is freely exposed passing into the defect of the vertebral column or of the skull. The sac is then opened widely enough to allow inspection of its contents, care being taken not to injure the nerve roots or spinal cord which may be attached. Nerve roots or the filum



Fig 192—Plastic repair of cranium bifidum with encephalomeningocele. 1 and 2 Dissection of the skin from the sac. 3 opening made into the sac and exposure of the cerebellum and choroid plexus. 4 the formation of a fascial tent over the collapsed sac with fascia lata obtained from the infant's father. 5 horizontal section of the repair.

A circular incision is carried around the body of the protrusion so as to preserve as much good skin as possible. The skin above the incision is peeled off to the apex by sharp dissection. Even a parchment-like covering will come off intact like a transparent hood if sufficient care and patience are exerted. The skin below the incision is then reflected

terminale should be dissected free from the sac if this can be done without injury to them. Otherwise nervous elements and even spinal cord should be left attached to the sac. Electrical exploration with weak faradic and galvanic currents aids greatly in the identification of nervous tissue which is capable of responding and is always carried out

efore the cystic cavities which are present in the spinal cord are opened and drained, so as to be certain that the incision will pass through functionless tissue.

When the sac of the meningocele contains cavity, as it usually does, the fluid is evacuated and the incision is then closed with interrupted sutures. If the sac contains only puggy tissue with small loculi, fluid will seep from it when it is cut across, and it is treated in the same manner. The collapsed

In some cases the sac itself has a dense capsule near its base, and if it is rolled over on itself, the uppermost wall of the sac proper will serve as a tent if the edges are fastened to the deep fascia by interrupted sutures. A further fascial layer may or may not be sutured over this. Buried sutures are then taken to approximate the skin edges so that the skin can be sutured without tension. The skin closure requires ingenuity at times if the protrusion is large

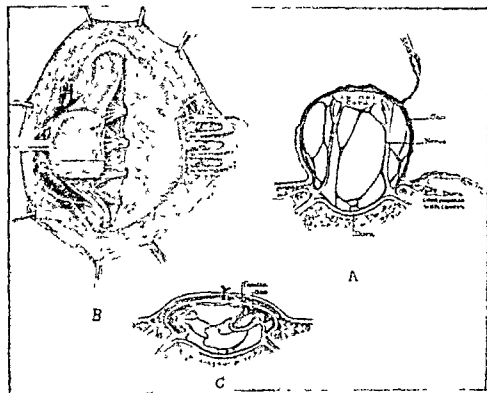


Fig 193—Plastic repair of spina bifida with lumbosacral myelomeningocele. A, Schematic representation of findings at operation before relationships were disturbed and also the beginning dissection of skin from the sac; B, the sac is collapsed and covered with a cotton pad to protect it during retraction. The nerve roots leaving the involved segments of the cord and passing to the intervertebral foramina through tissue of the sac are shown; C, schematic representation of the plastic repair. The sac is covered by a fascial tent made by reflecting and suturing fascia from the lumbar muscles over it. With the collapse of the sac, the nerve roots lie in folds and cannot be stretched as they were when the sac was distended with cerebrospinal fluid.

and closed sac is rolled up or placed in a heap. It is impossible to get it all into the spinal canal or cranial cavity. Instead, it is left *in situ*, and a fascial tent is made over it.

The tent of protective fascia may be secured from the fascia lata of the father's thigh. In most cases, however, the sac is too great in volume to be covered by flaps of deep fascia which carpets the adjacent bone and muscle of the infant. These flaps are cut and turned over the sac, the attachment to the bony defect being preserved.

and covered partially by parchment-like epithelium. Great care must be given to hemostasis to prevent hematoma. We usually institute drainage for twenty-four hours through a stab wound and use silk sutures throughout.

It is perhaps unnecessary to point out that all measures which aid in preventing shock should be employed in operating on young infants. Control of hemorrhage and prevention of chilling are two of the most important rules to be observed.

**Postoperative Treatment**—The infant should be moved to its bed without changes in position that is prone and with head down in the case of spinal protrusion in order to prevent loss of cerebrospinal fluid. Feedings are resumed as soon as the baby will nurse. Until the wound is healed the child is kept prone, the feet being tied in position if necessary. This prevents soiling and keeps the dressing dry.

After the wound is healed the head of the infant's crib is kept elevated. If the fontanelle pressure is high the parents are instructed to aid the absorption of fluid by postural and dehydration treatment as follows. The head of the crib is raised as much

**Selection of Cases for Operation**—In all cases of simple meningoceles and uncomplicated myelomeningoceles surgical treatment should certainly be carried out. The decision for or against operation in cases in which there are associated defects and complications must remain largely a matter of individual opinion. The associated anomaly hydrocephalus has led us to advise against surgical intervention as have the related or secondary complications which are extreme, i. e. complete paralysis of the sphincters and complete paralysis of the extremities. We have been gratified in many of the cases of myelomeningocele by the improvement in signs following operation. While damage

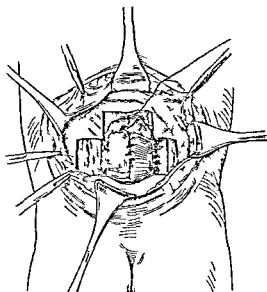


Fig. 194.—Plastic repair of lumbosacral myelomeningocele. Flaps from the deep fascia are being used to cover the collapsed but intact sac.

as possible. When the infant is carried it is kept erect, never horizontal. With the advice of a pediatricist the fluid intake is reduced to a minimum and the diet is changed to a solid one very early, although the bowels may become constipated as the result of fluid restriction. We have used these procedures for the past twelve years and have found them most helpful in the treatment of borderline cases of hydrocephalus when the absorption of fluid is only a little less than the formation of fluid. As a postoperative precaution it not only serves to reduce intracranial venous pressure, thus promoting the absorption of fluid, but it raises the pressure in the spinal sac and probably promotes escape there.

Already done cannot be repaired, relief of tension due to traction on the cord or nerve roots by the bulging sac must account for this improvement. Some of the little patients thus operated on may never be able to join the joyous crowd at the piper's back, but can nevertheless live happily and usefully.

**Optimum Time for Operation**—Plastic repair of meningoceles, encephalomeningoceles and myelomeningoceles should be carried out at the end of the third or fourth week of life when conditions are optimum. At this time the mother can come to the hospital. The supply of breast milk is well established and the dangers of hemorrhage and sepsis are much less marked than in

the newly born. If the sac is so thin that rupture is imminent and repeated punctures are contraindicated, earlier operation is advisable. When the sac is ulcerated or has already ruptured at birth, operation is carried out at once. When a patient is seen late and ulceration is present, it is necessary to wait until complete epithelization is well established before attempting the procedure; otherwise meningitis is almost inevitable. During the waiting period, the tension in the sac may be kept down by repeated aspiration, a needle being inserted through normal skin of the back well to the side of the defect. A doughnut made of cotton wool will protect the sac from trauma if nursing care is sufficiently expert.

The time of operation is a much disputed question. Many surgeons prefer to wait nine or ten months, meanwhile carrying out successive punctures; some advise waiting until the child is five years of age. Frazier states that 80 per cent of the untreated patients die during the first year. Plastic repair carried out early saves many of these lives.

**Discussion.**—Many years ago John Hilton pointed out the dangers of the methods of treatment of the disease called spina bifida; then current. He warned the students of Guy's Hospital in 1863 against the use of the knife and found it safer to tap and bandage the protruding cystic sac than to inject or ligate it. The present knowledge of the relationship of the cavities of the sac to the subarachnoid space makes one shudder at the practice of injecting iodine into these protrusions.

The development of aseptic technique has prevented in large measure the postoperative meningitis of Hilton's time, but the reports in the literature since its adoption are still discouraging. The failures which have followed the procedure of amputation, even in the most expert hands, are due to the fact that in a large percentage of cases the amputated sac has an important, sometimes indispensable function to serve. Moore estimated that the operative mortality was 50 per cent in the series of case reports that he collected. Craig, describing the attitude at the Mayo Clinic, also gives the operative mortality of 50 per cent if amputation is carried out at an early age. Cutler's figures were nearly 60 per cent.

The operation we have described provides for the preservation of the sac beneath a protective tent of fascia so that it can continue to absorb cerebrospinal fluid. Operation therefore does not increase the likelihood of the development of hydrocephalus as it does when the sac is amputated, and hydrocephalus has not developed postoperatively in our cases. The operative mortality has been reduced to 14 per cent in spite of the fact that it is our custom to operate at the end of the third week of life or at once if the sac is ulcerated or ruptured. Postmortem studies have shown the presence of associated anomalies except when death resulted from infection, indicating that surgical treatment was ill advised in these instances.

A point which can be raised in criticism of the surgical technique as we are carrying it out in the Neurosurgical Clinic of the Montreal Neurological Institute concerns the method of treating the spinal cord tissue which is adherent to the sac in cases of myelomeningocele. Thus far it has been a theoretical point, although our longest follow-up is but twelve years. We have never excised nervous tissue in the cases of spina bifida, even though it was so redundant that it could not be returned to the vertebral canal. In spite of Keiller's conclusion as a result of anatomical studies that attached cord usually shows no tissue which is capable of functioning and should therefore be removed at operation, we have so frequently obtained responses when it was stimulated electrically that we have not dared to remove it. It is possible that in some of our cases signs due to fixation of the cord may yet develop as they have in some occult cases, and further surgical attempts to free these may be necessary. The problem of fixation of the cord, however, can be left to the ingenuity of the neurosurgeon. It is not an immediately urgent problem like that of the protruding meningocele.\*

WILLIAM CONE

\*I have borrowed extensively from the experience of my colleagues Dr. Walter Lenfield and Dr. Arthur Elvén for this presentation and trust that I have fairly presented our joint views.



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## HYDROCEPHALUS

**General Description**—The typical picture of hydrocephalus is seen in the infantile cases in which the head is huge and heavy. The increased pressure of the cerebrospinal fluid in the greatly dilated ventricles has forced the yielding skull with its open fontanelles and sutures to expand, producing the grotesque head with the large calvarium

and overhanging forehead above the greatly stretched upper eyelids and a normal-sized face, which appears small by contrast (Fig. 195). This condition in infants is commonly caused by malformations or developmental errors and is termed *congenital hydrocephalus*. Hydrocephalus which develops in adolescence or adult life is usually the result of a brain tumor and is termed *acquired hydrocephalus*. In these cases the head is not enlarged, as the skull has become a firm bony box after the closure of the sutures, and the pressure of the cerebrospinal fluid results only in the enlargement of the ventricles by compression of the brain tissue against the skull.

The accumulation of the cerebrospinal fluid may be rapid or slow. In some instances a balance may be established with no further accumulation of fluid, and the hydrocephalus is thus arrested. If, however, the aggregation of fluid began in infancy the large head persists.

**Types of Hydrocephalus.**—*Obstructive, Internal or Non-Communicating*—The dilatation of the ventricular system may be due to a block somewhere in its course so that the cerebrospinal fluid, which is formed by the choroid plexus of the lateral ventricles, is unable to escape into its absorbing channels. This obstructive or non-communicating type of hydrocephalus is unilateral if the block occurs in the region of one foramen of Monro. Bilateral enlargement of the lateral ventricles would be produced if the obstruction occurred (1) at both foramina of Monro, (2) or in the third ventricle, (3) or in the aqueduct of Sylvius, (4) or in the fourth ventricle or (5) at the midline foramen of Magendie and the lateral foramina of Luschka of the fourth ventricle (Fig. 196).

**Communicating, External.**—Communicating or external hydrocephalus produces the same dilatation of the ventricular system as occurs in the non-communicating type, but the blockage is found in the absorbing spaces for the cerebrospinal fluid. The absorbing channels consist of large lakes or cisterns along the base of the brain between the pia mater and pia arachnoid which communicate with the subarachnoid spaces over the surface of the cerebral and cerebellar lobes and the spinal cord.

**Etiology.**—In the non-communicating or obstructive type of hydrocephalus the block in the ventricular system may be due to (1) malformations of the brain, such as atresia or absence of the foramina, of the aqueduct of Sylvius, or of a cerebral hemisphere, diaphragms or vascular bars in the aqueduct or third or fourth ventricle, (2) malformation of the skull distorting the brain stem and obstructing the aqueduct or cisternae, as in achondroplasia, (3) strictures resulting from inflammatory conditions or (4) tumors (cystic, vascular or solid) in the midline structures: septum pellucidum,

stricture and prevent absorption of the cerebrospinal fluid. Tumors in the leptomeninges, such as medulloblastoma, endotheliomatosis or gliomatosis of the meninges, that seed themselves throughout the subarachnoid channels may produce moderate grades of hydrocephalus by interfering with the absorption of the cerebrospinal fluid.

**Symptoms and Signs.**—In infants, because of the yielding of the skull and subsequent enlargement of the head, few or no signs and symptoms of increased intracranial pressure may be manifest. Usually there is a retardation in mental development, but it



Fig. 105.—An extreme case of hydrocephalus. This boy, aged three years, had an almost normal mentality.\*

corpus callosum, suprasellar region, pineal region, midbrain, pons, cerebellar lobes and vermis.

In communicating hydrocephalus the cisternal and subarachnoid channels may be occluded owing to an inflammatory process or arachnoiditis, which produces scarring and adhesions in the meninges. The meningitis may be the acute type from bacterial invasion of the streptococcus, pneumococcus, meningococcus, etc., or it may be the subacute or chronic type seen in tuberculous, syphilitic and mycotic infections. Hemorrhages in the cisternal and subarachnoid cerebral spaces may lead to fibrosis and

is surprising the extensive compression of the cerebral tissue that may take place without causing appreciable mental changes.

When the skull is unyielding, after the closure of the fontanelles and sutures, and forms a bony box with only one opening (the foramen magnum), hydrocephalus will produce the symptoms of general increased intracranial pressure. These are (1) headaches, generalized or occipital, (2) vomiting, which frequently occurs without nausea or relation to meals and is often forceful so that it has been termed projectile, and (3)

\* Dandy in Lewis: *Practice of Surgery*. W. F. Prior Co., Publisher.

failing vision. Double vision, usually due to weakness of the sixth nerve, may be present but is of no localizing value.

Signs of increased pressure appear as irritability or drowsiness, slowed pulse and respiration, increase in the blood pressure, edema of the optic nerve heads (called papilledema or choked disk) with at times exudate or hemorrhages in the retina as seen by ophthalmoscopic examination. A high-pitched percussion note or cracked-pot sound, Macewen's sign, indicates a thinning of the skull due to internal pressure. This is

sure, the cracked-pot sound on percussion of the head and convolutional atrophy of the skull.

The diagnosis, however, cannot be made with certainty from these findings since any space-occupying lesion within the skull, such as tumor, hemorrhage, cyst, subdural hematoma or hydroma, may develop without the production of hydrocephalus and give the same symptoms and signs both in infants and in adults.

A definite diagnosis of hydrocephalus can be made by Dandy's method of ventricu-

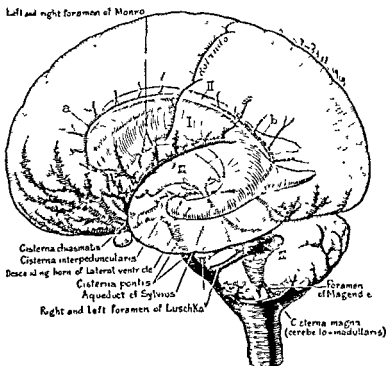


Fig 196—General plan of the cerebrospinal fluid system. The only exits by which the ventricular fluid may reach its absorbing bed in the subarachnoid spaces are through the paired foramina of Luschka and the median foramen of Magendie.\*

confirmed by the convolutional atrophy seen in the roentgenogram (Fig 197).

**Diagnosis.**—Hydrocephalus in the infant is recognized by the enlargement of the skull, the peculiar appearance of the eyes caused by the stretching of the upper lids, the bulging fontanelles and separated sutures, varying grades of mental and physical retardation and the symptoms of increased intracranial pressure, if they are present.

Hydrocephalus in the child or adult will present one or all of the symptoms and signs of generalized increased intracranial pres-

sure. This consists of withdrawing ventricular fluid by means of a needle, introduced into the lateral ventricle either through a trephine opening in the skull or through an open fontanelle or suture and replacing this fluid by air. Roentgenograms taken after this procedure will outline the ventricles. A normal ventricle contains from 10 to 15 cc. of fluid. A capacity greater than 30 or 40 cc. for both lateral ventricles is indicative of hydrocephalus (Fig. 199). Any abnormal change in the shape, size or position of the parts of the system.

\* Dandy. Bull. Johns Hopk.

will be apparent in the ventriculogram and is of value in localizing the site of the cerebrospinal fluid block which is producing the hydrocephalus. For instance, failure to visualize the third ventricle completely or partly would indicate an obstruction in this region or a dilatation of the third ventricle along with that of the lateral ventricles would locate the obstruction in or posterior to the aqueduct of Sylvius.

Röntgenograms after the replacement of the cisternal and subarachnoid fluid by air (Dandy's encephalography) may be obtained to determine obstructive areas in the absorbing system. The injection of air is made through a needle introduced into the cisterna magna (cisternal puncture) or into the spinal subarachnoid space by spinal puncture. There is a real hazard in the spinal injection of air unless the increased intracranial pressure has first been reduced by removal of some of the ventricular fluid, otherwise lowering the pressure of the spinal fluid may cause a herniation of the tips of the cerebellar lobes into

The Dandy and Blackfan phenol-sulfone-phthalein test may be utilized in making this differential diagnosis. Neutral phenol-sulfonephthalein, when introduced into the spinal subarachnoid spaces, diffuses upward

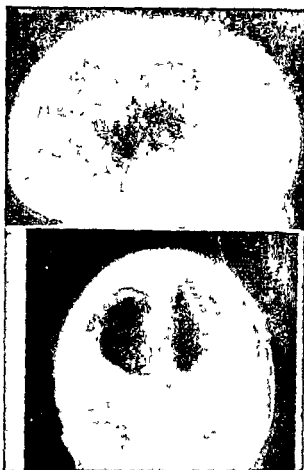


Fig. 198.—Ventriculograms lateral and anteroposterior, showing the huge dilatation of the ventricles in hydrocephalus.

so that from twenty to thirty minutes after 1 cc. has been injected in the absence of obstruction in the ventricular system the dye can be detected in the aspirated ventricular fluid by its pink color after the addition of a few drops of sodium or ammonium hydroxide. All specimens of urine are saved for the first two hours and tested quantitatively for the dye. Normally the yield from the spinal subarachnoid spaces is less than 10 per cent, and for the combined cerebral and spinal subarachnoid channels it is between 30 and 40 per cent. A yield of from 10 to 20 per cent, therefore, would indicate a severe grade of communicating hydrocephalus.

This test provides the most satisfactory



Fig. 197.—Röntgenogram showing the convolutional atrophy of the skull of a youth with communicating hydrocephalus.

the foramen magnum which will compress the medulla and lead to respiratory failure.

Although hydrocephalus can be definitely diagnosed by ventriculograms, this procedure may not afford a differentiation between the non communicating and communicating types especially in infants.

method of differentiation between the more common obstructive type and the rarer communicating type of hydrocephalus in infants and children and permits the selection of appropriate therapeutic measures.

**Treatment**—Non communicating hydrocephalus in the youth or adult is usually produced by a tumor and is relieved by its removal.

The arrest or cure of hydrocephalus in infancy has interested physicians for centuries. Instances of spontaneous arrest are not uncommon and there are records of cases in which the frequent withdrawals of cerebrospinal fluid and a limitation of the general fluid intake stopped the progression of the accumulating fluid. But too frequently the rapid development of fluid and the progressive enlargement of the head call for surgical intervention.

Surgical treatment for the obstructive type of hydrocephalus has varied from the drainage of the ventricle into the subcutaneous or subdural spaces or into the blood stream by means of tubes or segments of vessels or by holes punctured through the corpus callosum into the ventricles to the establishment of a new aqueduct of Sylvius by the tube method or a new outlet made in the posterior velum when the obstruction is at the foramina of Luschka and Magendie. If the ventriculograms fail to show the localized area of the block and the phenolsulfonaphthalein test indicates the presence of normal absorbing channels several satisfactory procedures are available.

One method attempts to establish a free communication between the floor of the third ventricle and the underlying cisterna and interpeduncularis (Dandy's third ventriculostomy).

Another operation consists of removal of the choroid plexuses of the lateral ventricles either by resection or by their destruction with the electrocoagulating current. This choroidectomy will markedly diminish the formation of cerebrospinal fluid.

Treatment of the communicating type of hydrocephalus when exploration has revealed that it is due to multiple tumors in the meninges as in medulloblastomas may be cured for a time at least by applying deep roentgen therapy to the entire brain and spinal cord. A more common cause of com-

municating hydrocephalus is the sealing off of the cisternal and subarachnoid cerebral spaces by a chronic arachnoiditis which develops as a distressing sequel of meningitis. It is impossible to reopen these channels surgically; hence removal of the choroid plexuses is performed to diminish the formation of the fluid or if the spinal subarachnoid spaces are patent their continuous drainage into the peritoneal or retroperitoneal spaces or into a ureter after removal of a kidney may be attempted.

The surgical treatment of hydrocephalus, owing to the varying causative factors has not been brilliantly successful except in those cases in which the removal of a bar, diaphragm or tumor could be accomplished. One is justified in undertaking surgical measures in all other conditions producing hydrocephalus to prevent further destruction of brain tissue and progressive increase of the intracranial pressure which would continue and lead to death.

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#### INTRACTABLE PAIN\*

**Definition**—Intractable pain is defined as that type of pain which does not yield to adequate and specific treatment of the underlying pathologic condition and which necessitates relief.

**Etiology**—The etiology of such pain is extremely varied and may range from disease of an unknown pathologic nature such as trigeminal neuralgia to lesions such as carcinoma of the bladder or malignant metastases to the spine. Among painful affections usually requiring relief of some sort may be listed migraine, trigeminal gloss-

\* See the section on the Autonomic Nervous System.

sopharyngeal auricular occipital intercostal and anterior crural neuralgia, Raynaud's disease, angina pectoris, malignancies of all kinds both primary and metastatic tuberculosis of the larynx, tuberculosis of the genitourinary tract, gangrene or vascular insufficiency in the extremities of various etiologies, cruralgia, intractable peripheral neuritis such as chronic sciatica, herpes, injury, inflammation or inoperable neoplastic disease involving spinal nerve roots or the cauda equina, atypical facial pain of possible sympathetic origin, visceral pain of unknown origin and even dysmenorrhea. Rarely, cerebral disease, either cortical or thalamic, has been said to produce pain.

**Treatment**—The treatment of intractable pain depends on its origin its location the nature of the structures it involves the probable prognosis the life expectancy of the patient and his physical and psychical status. It should also always be understood that all possible underlying causes have been previously considered, investigated and specifically and sufficiently treated without avail by the most adequate methods including roentgen therapy, if indicated.

In general the subject of treatment may be classified under the headings of psychotherapy, medication specific and non specific, nerve injection and operation.

**Psychotherapy**—It is evident that pain a subjective phenomenon may manifest itself in different degree in different persons. It is therefore necessary to evaluate patients and to form an opinion as to the actual presence of pain and as to its nature and intensity. There is no question but what the background of some pain is psychic and not organic, and it is also true that even tangible organic pain may be greatly exaggerated by some patients and minimized by others. Conditions which may affect these characteristics beside those inherent in the patient, are the type of pain the frequency of attacks the length of time pain has been present and additional factors such as drug addiction etc. Psychotherapy therefore enters in some measure into the alleviation of all painful afflictions perhaps most in neural and visceral pain of unknown origin and least in trigeminal neuralgia.

**Medication**—But few of the painful affections listed in this chapter are amenable

to specific medication. Chief among them are trigeminal neuralgia, angina pectoris and migraine. In about two thirds of all cases trigeminal neuralgia may be temporarily relieved by inhalation of trichlorethylene. This drug however loses its efficacy in a few months and overdosage with it is likely to produce undesirable effects such as nystagmus, tinnitus and vertigo. In the same way anginal prooxysms may be relieved for the moment by vasodilating compounds such as amyl nitrite. Migraine frequently responds to ergotamine tartrate.

Most pain however must be treated as far as drugs are concerned by narcotics. If there are contraindications to injection or operative therapy either because of inaccessibility or of the poor condition of the patient resort must be had to these substances. It is well however to give as small amounts as possible from the beginning since the demand usually becomes greater as time progresses, and the results of addiction are often as distressing as the original disease. Codeine is not habit forming and it is frequently feasible to give combinations of codeine hypnotics and mild analgesics for some time before morphine or its derivatives become necessary.

Adjuncts to treatment by medication which are occasionally of value are the induction of local heat or cold and x-ray treatment.

**Injection**—The most direct method of dealing with intractable pain is to attack somewhere along its course the pathway by which it is conveyed from the painful region to the thalamus and sensory cortex of the postrolandic area of the cerebrum. The simplest and least permanently damaging device is the injection of various substances in or around the spinal or peripheral nerves.

Novocain is a useful drug for such purposes because it is a temporary but complete anesthetic. It is frequently, therefore a good plan to precede further therapy by a diagnostic injection with novocain since this drug may serve to establish the presence of pain and to identify the particular nerves conveying it.

Saline solution is sometimes used by injection directly into a nerve trunk or around spinal nerves. The theory is that forcing large quantities of fluid into such areas has

a tendency to break up inflammatory adhesions which may be responsible for pain. The commonest sites for saline injection are the sciatic nerve into which it is injected for chronic sciatica and the epidural space at the lower end of the spinal canal into which it is injected for the relief of pain thought to arise in the filaments of the cauda equina as they leave the dura. It is felt by some that addition of various drugs such as novocain or quinine derivatives to the saline has a beneficial effect but most surgeons believe that any relief will be obtained as well by the use of saline alone.

Alcohol has long been used for nerve injection because its effect is to transect the nerve physiologically without destroying its continuity so that there is eventual regeneration. The usual strength used is 80 per cent in normal saline or in 1 per cent novocain-saline solution. Alcohol must be injected directly into the nerve itself in order to take effect since it does not infiltrate tissue as does novocain owing to its tendency to wall itself off by precipitating the tissue protein with which it comes in contact. It goes without saying that alcohol should not be injected into a mixed nerve the motor portion of which is essential to normal function.

Nerve injection with alcohol is a rather common procedure. The most frequent sites for its use are the various accessible divisions and branches of the trigeminal nerve the superior laryngeal nerves in tuberculosis of the larynx the intercostal nerves and painful amputation neuromas.

Injection of absolute alcohol into the dural sac has recently become a part of the therapeutic armamentarium for pain arising chiefly in the lower abdominal viscera and lower extremities. The patient is placed on his side and lumbar puncture is carefully performed at the first lumbar interspace. When the end of the needle is known to be in the subarachnoid space and not in contact with the conus medullaris and the upper part of the cauda equina which lie in that region 1 cc. of absolute alcohol is slowly injected. The side of the patient on which the pain is most severe is usually placed uppermost since the alcohol will rise in the cerebrospinal fluid. The injection may be repeated once or twice at intervals of a week or ten days and a number of authors have

reported the obtaining of pronounced relief without the production of appreciable objective neurological signs. It should be borne in mind however that this procedure may eventually result in chronic inflammatory change in the central nervous system and it should therefore be limited in most cases to use in patients whose life expectancy or whose necessity for an intact spinal cord is not of long duration.

**Operation.**—Operation on the central sympathetic or peripheral nervous system for the relief of intractable pain should be performed only when other means of alleviation are not indicated or have failed. It is bad medical philosophy to interfere with a normal structure for the sake of a pathological one except out of necessity. Such operations however may become necessary and it is possible to classify them under the headings of neurolysis peripheral neurectomy posterior rhizotomy chordotomy and sympathectomy.

Neurolysis is the term used to describe the operative breaking up of perineural adhesions. It must occasionally be performed for pain arising in adhesions formed after injury particularly around the great nerves of the upper extremities. "Nerve stretching" of the sciatic nerve for chronic sciatica is also a form of neurolysis.

Peripheral neurectomy is performed in cases in which the pain seems to be limited entirely to the nerve in question as far as the conduction pathway is concerned. Nerves which may come into this classification are the supraorbital the glossopharyngeal the greater and lesser occipitals the cutaneous branches of the anterior crural etc. It should be remembered however that such nerves will regenerate if given an opportunity and that in the case of nerves which exit from foramina in the skull it is impossible to prevent regeneration. It is for this reason that neurectomies of the branches of the trigeminal nerve have given way entirely to alcohol injection when posterior rhizotomy is refused or inadvisable. The exception is the supraorbital nerve whose parent division cannot be injected because of its proximity to the third fourth and sixth nerves. In such cases neurectomy is better than peripheral injection because it is often possible to avulse several centimeters more

of nerve through the superior orbital foramen than could be reached by alcohol

The subject of peripheral neurectomy would not be complete without mention of the treatment of migraine by interrupting the dural sensory supply which follows the course of the meningeal vessels. This is accomplished by double ligation and division of the middle meningeal artery as it enters the skull through the foramen spinosum

Posterior rhizotomy is the section of a sensory cerebral or spinal nerve root central to its ganglion of origin. It has the advantage of producing a permanent sensory loss because of the absence of regeneration owing to the lack of neurilemma sheath and of causing no interference with motor function. I except in the case of trigeminal neuralgia however this operation has lost favor in recent years except in cases in which pain arises from isolated spinal nerves such as that seen in persistent intercostal neuralgia or in intractable tabetic root pain. The reason for this is the tremendous overlap in the areas supplied by spinal nerves which necessitates the sectioning of many more roots than is practical in order to produce the desired anesthesia

Chordotomy is the operation which has largely supplanted posterior rhizotomy. It consists in sectioning that portion of the spinal cord which contains the lateral spinothalamic tract and conveys the sensations of pain and temperature. The accompanying diagram shows this area (Fig. 193). A small part of the anterior gray column has also been included since some observers believe that visceral sensation is herein carried cephalad by short chain pathways

The section illustrated will produce analgesia up to a point within a segment or two below the level of the operative lesion on the side of the body opposite to that on which the lesion is made. Bilateral chordotomy will of course produce bilateral analgesia and it can be done at any level up to the midcervical region in which the phrenic nuclei are situated. Unilateral chordotomy in the middle or upper cervical cord is sufficient but a bilateral operation here particularly as a one step procedure is fraught with danger of respirators paralysis

This operation is at present the best known and the one most frequently used for

the relief of intractable pain. A properly performed unilateral lesion is entirely benign. Bilateral lesions however produce a loss of ejaculatory reflex although they do not otherwise render patients sexually incapacitated and they also frequently cause temporary though not often permanent loss of sphincter control

A recently proposed variant of chordotomy which should be mentioned is the production of an artificial syringomyelia by division of the median commissures of the spinal cord. This results in a localized bilateral loss of pain and temperature sensation its extent being dependent on the length of cord involved in the operation. It may prove a useful substitute for the dangerous high cervical bilateral section of the antero-lateral tract

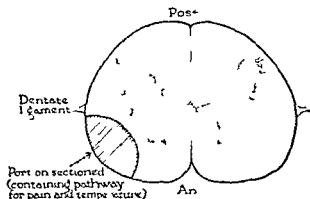


Fig. 193.—Diagram showing portion of spinal cord sectioned in the operation of chordotomy for the relief of intractable pain

Sympathectomy is in some respects the most recent addition to the list of procedures for the relief of pain. Paravertebral sympathectomy is a fairly old operation but in recent years operations on the main sympathetic pathways have come more into favor. Section of the hypogastric plexus is performed for pain arising in the bladder or internal genitalia of the lumbar sympathetic chain for painful vascular disease in the lower extremities and of the thoracic and cervical sympathetic system for angina pectoris, Raynaud's disease and causalgia

Most of these procedures afford relief in some cases. However it is but fair to say that many have not stood the test of time. Nevertheless they are always to be seriously considered because of the possibility that they may be successful in otherwise desper



ate and intolerable situations, and they have the additional advantage of not interfering appreciably with essential bodily functions and even of being therapeutically helpful with respect to the underlying pathologic condition, as in the case of Raynaud's disease

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## XIV. ORTHOPEDIC SURGERY

### TUBERCULOSIS OF THE BONES AND JOINTS

**History**—Since the earliest days of medical history the pathologic condition now known as tuberculosis has been recognized. Its clinical character separates it from the more acute infectious processes. Long before Koch (1881) discovered *B. tuberculosis* this disease was known as white swellings, scrofula and surgical tuberculosis. For signs of acute inflammation were absent and the gross pathologic picture was that of multiple tubercle formation. Koch's momentous discovery with the classic application of his postulates established the infectious nature of this disease.

**Etiology and Pathology**—The infecting organism in tuberculosis may be of the human, bovine and rarely avian type as identified by cultural and morphologic characteristics. In the infectious processes of the bones and joints of man the human and bovine types of organism predominate. Infection is by direct or indirect contact with an open case or by ingestion of contaminated food. It follows contact with an open case of pulmonary tuberculosis, cases with draining sinuses or the ingestion of contaminated milk. Bone and glandular infections have a high incidence where the supervision and inspection of dairies is inefficient. Hereditary or prenatal infection is improbable. The natural resistance to *B. tuberculosis* is high when the quantitative infection is small as evidenced in the survival of the human race; the majority of persons having tuberculosis in an arrested form.

The susceptibility of different races to this infection differs. The Negro, Mexican and Indian are only slightly resistant; the yellow race is slightly more so, while the white race has the greatest resistance. Sex seems to have no influence on the incidence of this infection. Infections of the bones and joints predominate in early life; a large majority occurring between the ages of one and six years.

The joint or bone lesion is always secondary to pulmonary, gastrointestinal or glandular foci. The occurrence of a lesion in bone indicates that the resistance of the soft tissue is high. The route of infection is un-

doubtedly hematogenous; minute emboli of organisms lodging in the small capillaries adjacent to the epiphyseal cartilage.

The implantation of emboli is due to the peculiar anatomical arrangement of the smaller blood vessels prior to epiphyseal closure. Small infarcts form. Typical tubercles develop and grow circumferentially, destroying bone without stimulating reparative reaction and forming local abscesses. Extension to the joint results from destruction of the epiphysis and articular cartilages or by extension along the epiphyseal line to the capsule and synovia. Osseous or synovial pathologic conditions result. The involvement of the synovia is accompanied by signs of irritation; the amount of synovial fluid is increased and movement is restricted. Bone atrophy is common. The articular cartilage is detached by subchondral extension of granulation tissue. A tuberculous process differs from an acute pyogenic condition in that there is no redness or local heat. The swelling remains as the 'tumor albus' or 'cold abscess'.

**Diagnosis**—Clinical diagnosis is made late in the course of the infection for the course is insidious and the signs are indefinite. Three clinical types of pathology are found: (1) *cases sicca* in which the onset is insidious, the progress slow and no abscess is formed; (2) *acute* when signs are fulminating as in pyogenic joints; and (3) *subacute* when the symptoms are moderate but progressive. In a small percentage of cases bone or joint lesions may be multiple.

**Symptoms**—The symptoms of tuberculosis of a joint reflect the disruption of the normal physiology of the various joint structures. Swelling is most constant and is recognized by inspection, palpation and measurement of the joint. The normal joint markings are lost by the boggy thickening of the synovial structures. Muscle spasm which restricts joint movement so as to prevent greater irritation is always present. The tuberculous joint is usually monoarticular, thereby permitting comparison with the nor-

mal range of function of the uninvolved articulation

Atrophy of the adjacent soft structures though not diagnostic suggests the involved extremity. Pain is variable and not specifically diagnostic. Loss of length results from deformity, destruction of bone and disturbance of the normal epiphyseal growth. Characteristic deformities result from positions assumed for comfort from muscle contractions and also from bone destruction. The general symptoms such as loss of weight, secondary anemia and low grade temperature are frequently absent.

The clinical picture is never diagnostic for it may be simulated by many other types of infection. Positive diagnosis is made by the identification of B. tuberculosis in tissue obtained at biopsy or aspiration by the typical histopathologic tubercle formation or by recovery of B. tuberculosis by injection of infected material into the guinea pig. Dermal tests with tuberculin are useful in distinguishing the non-tuberculous from the tuberculous patient, the reaction being positive only in the presence of tuberculosis.

Atrophy and destruction of bone alterations of the joint space and the formation of an abscess revealed by the roentgenogram although not specific have diagnostic value. An early accurate diagnosis is necessary to prevent overtreatment of non-tuberculous and undertreatment of tuberculous lesions.

**Treatment**—Up to the present no specific treatment for tuberculosis has been generally recognized. Preventive measures have made great strides and a lowered incidence results. Isolation of open cases and strict supervision of the milk supply have effectively reduced the number of tuberculous cases.

Treatment is along general as well as local lines. Wholesome hygienic living conditions, fresh air and a generous well balanced diet high in calcium and phosphorus salts are essential as is rest, general and local. Heliotherapy as popularized by Rollier is important and is indicated as an adjunct to local measures but exposure should be graduated and not overdone. During winter months the quartz mercury and carbon arc lights in moderate dosage are useful.

Local treatment consists of promoting functional rest in the involved joint by the

use of traction braces and splints and by surgical ankylosis. Abscesses are aspirated and treated without drainage unless secondarily infected. Deformity is corrected by traction, manipulation or operation.

### TUBERCULOSIS OF THE SPINE

**Pathology**—Tuberculosis of the spine (Pott's disease) is first in incidence among osseous tuberculous lesions. It is more frequent in children but may occur at any age.



Fig. 900.—Pott's disease involving the lower lumbar area, showing destruction of the vertebral bodies and its relation to the terminal roots of the spinal cord.

The sites of tuberculous lesions in order of frequency are the lower dorsal, upper dorsal, upper lumbar, lower lumbar and cervical vertebrae. The intervertebral process is located along the cartilage plate of the vertebral body, resulting in early absorption of the intervertebral disks and destruction of the adjacent areas of the vertebral bodies. Bone destruction is followed by collapse of the vertebral bodies and posterior angulation (*kyphosis*). Multiple areas of involvement are not un-

common. Abscesses form early. In the cervical region the abscess extends anteriorly, compressing the soft structures of the neck and at times extending extrapleurally into the upper portion of the thorax. In the dorsal area the abscess remains localized and is globular, giving evidence of posterior mediastinal pressure. Abscesses arising from the lower dorsal and lumbar portions of the spine extend along one or both psoas sheaths to the pelvis (*psoas abscess*), at times pointing in the femoral area after passing beneath Poupart's ligament. Less frequently lumbar involvement gives rise to abscesses pointing posteriorly in the lumbar area.

**Symptomatology.**—The symptoms of tuberculosis of the spine are irritation, compression of adjacent structures or interference with the function of the spinal cord and spinal nerve roots.

All movement of the spinal column is restricted by muscle spasm, motion and attitudes are protective. With cervical involve-

squatting position. Irritation of the spinal cord and nerve roots results in the reference of symptoms to areas remote from the area of the disease. Tension arising from abscess formation within the psoas sheath may suggest disease of the hip joint.



Fig. 201.—Tuberculosis of the upper lumbar spine with deformity.

ment, rotation of the neck is restricted or absent, and the patient supports the chin with his hands. In cases of dorsal involvement, interference with motion is somewhat less marked but is evident on flexion. Instead of flexing the spine in picking up objects from the floor, the patient assumes a



Fig. 202.—Roentgenogram showing tuberculosis of the spine at dorsolumbar juncture. Bilateral psoas abscess with marked calcification.

Deformity is a late manifestation of vertebral disease. Angulation is posterior and is in the sagittal plane except in rare instances. Multiple areas of disease may give rise to long, rounded kyphoses rather than the usual sharp angulation.

Involvement of the spinal cord is seen in the development of signs of transverse myelitis, in the more advanced stages, in complete paraplegia.

**Diagnosis.**—The diagnosis of vertebral tuberculosis is confirmed by changes in the roentgenograms. The intervertebral space is thin, deformity is evident, bone destruction is present and aspiration of abscesses may yield *B. tuberculosis*.

**Treatment of vertebral tuberculosis** consists of all measures employed in a general type of the disease combined with immobilization of the spine, accomplished by rest in bed, support on a firm frame, plaster shell or

brace until healing by bony consolidation of the diseased area is complete. Prolonged recumbency is necessary. Internal splinting may be accomplished by a spinal fusion op-

the marginal epiphysis of the acetabulum or the synovial structures of the joint. Bone destruction may be limited to the upper end of the femur or to the acetabulum. Hip



Fig 203—Tuberculosis of the spine Showing the use of a hyperextended Bradford frame.

eration or by means of a bone graft in order to solidify the pathologic area. Abscesses are aspirated through firm tissue and drained if secondary infection is present.

disease usually occurs in children under ten years of age, and trauma undoubtedly plays an important rôle in the localization of the disease by lowering the local resistance.

**Symptomatology.**—In the early stages of infection of the hip joint the symptoms are



Fig 204—Tuberculosis of the right hip. Fixation in plaster splint after operative fusion.

#### TUBERCULOSIS OF THE HIP

**Pathology.**—The incidence of tuberculosis of the hip joint is second to that of vertebral tuberculosis. The initial lesion is located in the epiphysis of the upper end of the femur,



Fig 205—Tuberculosis of the spine. Support obtained with a spinal brace.

transient and evidenced by a slight limp. Signs of irritation gradually become more marked, and muscle spasm in all directions increases. The thigh is flexed and adducted causing the leg to appear short. In the early stages, pain is referred to the medial aspect

of the knee joint along branches of the obturator nerve. Atrophy of the buttock and thigh is recognized by inspection, palpation and measurement. Abscess formation often is extensive.

**Diagnosis.**—Roentgenologic examination reveals capsular swelling, bone atrophy and destruction of the femoral head or acetabulum, or both. Subluxation may be present

### TUBERCULOSIS OF THE KNEE

**Etiology and Pathology.**—Tuberculous infection of the knee joint is always secondary to a primary lesion involving the lungs or the gastrointestinal tract. *Transmission* to the knee joint is through hematogenous channels. In children the bacterial emboli lodge in the epiphyseal cartilage forming a localized tubercle. This focus increases by



Fig 206—*a*, Tuberculosis of the right hip of five years' duration *b*, roentgenogram made two years after a fusion operation

A positive diagnosis is established by aspiration and in some cases by biopsy of the diseased area.

**Treatment.**—*Local treatment* consists of immobilization of the joint in a position favorable for function after ankylosis of the joint. Traction, casts and splints are used extensively. Fixation of the joint by operation is the procedure of choice of many surgeons, as the ankylosis of the joint is more rapid and prolonged recumbency is avoided

progressive destruction of bone and enters the knee joint by extension along the capsular structures or directly through the articular tissues. Within the joint the synovial response is that of irritation. A synovitis is present as is indicated by the increase of synovial fluid, normal landmarks of the joint are lost and the synovia becomes thickened and studded with tubercles. Pannus formation covering the articular surfaces is common.

**Symptomatology.**—The joint disability parallels the destruction of the various joint structures. The muscles of the thigh are in spasm and soon show signs of atrophy. Active and passive motion of the joint is painful. Roentgenograms reveal the location of the destructive process along the epiphyseal line with occasional sequestrations (Fig 209, a). Atrophy of the bone adjacent to the joint is present. As the disease progresses, destruction of the epiphysis becomes more marked, and abscesses form and

joint conditions. A positive reaction to tuberculin, although not positive proof as to the infectious agent, facilitates diagnosis. In order to prevent overtreatment of a non-tuberculous joint and undertreatment of a tuberculous joint, an accurate diagnosis is essential. This is obtained only by recovery of *B. tuberculosis* on aspiration or biopsy.

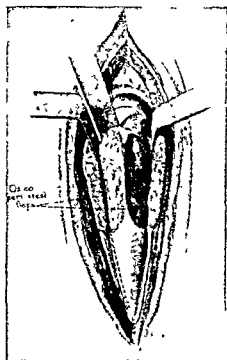


Fig 207—Heavy grafts (A and B) of cancellous bone are reflected from the anterolateral and posterolateral aspects of the greater trochanter. The periosteal and muscular attachments of these grafts are not disturbed. A massive graft including the greater trochanter, lateral surface of the neck, and a portion of the cortex of the shaft is removed by converging cuts.\*

extend along fascial planes. The popliteal lymph glands increase in size and may break down, forming sinuses.

**Diagnosis.**—The early clinical picture of such a condition in the joint cannot be accurately differentiated from other types of infection without specific data. In a child below the age of six years, the reaction to tuberculin is significant. A negative von Pirquet or, better, a negative intradermal tuberculin test (Mantoux) is useful in ruling out tuberculosis in otherwise questionable

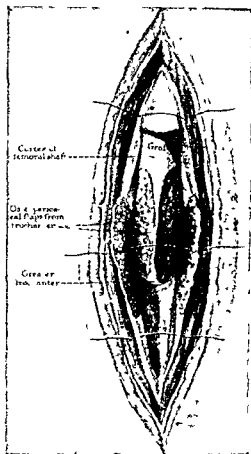


Fig 208—The trochanter graft is turned end for end and shaped for maximum contact. The cortical portion is then driven firmly into the recess on the lateral surface of the ilium. The thigh is abducted to establish firm contact with the graft. The osteoperiosteal grafts are firmly sutured over the free end of the massive trochanteric graft, and the wound is closed without drainage.\*

aided by guinea-pig inoculation, or by the identification of the tubercle in the involved tissue. In adults the clinical picture is of a low grade synovitis of a progressive nature. The onset is insidious, the swelling is marked but redness and pain except on motion are noticeably absent. Roentgenograms show bone atrophy with or without destruction of bone.

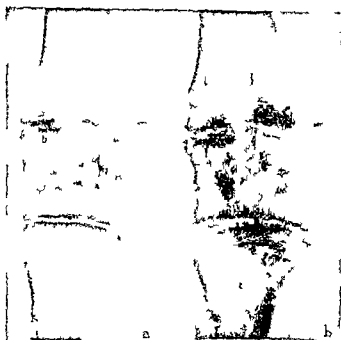
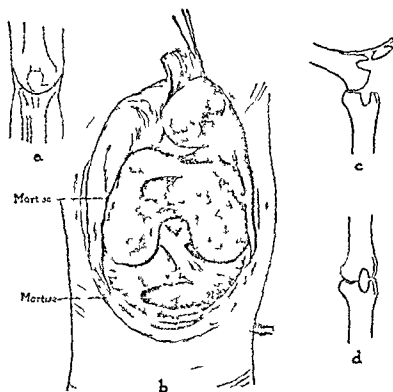


Fig. 209—*a* Tuberculosis of the knee with destruction of the articular surfaces *b* after an operative fusion of the knee joint





Local rest of the joint is important and may be accomplished by the use of splints, casts and braces. With this regime arrest of the disease process is favorable but extremely slow. With the most satisfactory progress, healing of the lesion with the preservation of useful motion is the exception rather than the rule, as verified in the treatment of joint disease in adults.

Operations to aid the process of ankylosis in adults are well accepted and widely employed, but in children the operative course has been less favorably received, most surgeons preferring the prolonged fixation in

at the upper end of the tibia is removed and the semilunar cartilages are excised. The denuded surfaces of the femur and tibia are altered to correct any deformity. A mortise is then cut in the femur and tibia to receive the patella which is used as a graft. After the articular cartilage has been removed the patella is placed in the recesses of the femur and tibia and locked into place by extension of the joint.

The crucial and collateral ligaments are not disturbed and no attempt is made to remove patellofemoral synovia. The incision is closed without drainage and a spica cast applied, 90 degrees of flexion being desirable in adults. In children full extension of the knee is desired because of possible yield through the epiphysis. Early weight bearing is permitted. Bony union occurs in a high percentage of cases in six or eight months.

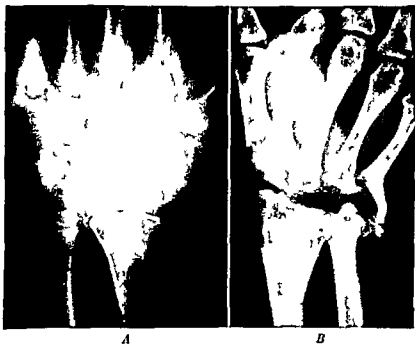


Fig. 211—A Tuberculosis of the carpus. B One year after excision of the carpal bones (film reversed)

plaster splint or brace during the period of growth.

Surgical treatment is directed toward the establishment of a bony ankylosis of the knee joint. Of many different procedures suggested and used, only the knee fusion of Hibbs will be described here.

A tourniquet is used for hemostasis. A curved incision is made across the anterior aspect of the knee joint extending from the lateral surface of the medial femoral condyle across the center of the patellar tendon and through to the lateral aspect of the lateral femoral condyle. The skin flap is turned up from the anterior surface of the patella. The incision is then carried through the aponeurosis, capsule and patellar tendon to permit the complete upward rotation of the patella. The joint is flexed. The articular cartilage of the femur

### TUBERCULOSIS OF THE ANKLE

Tuberculosis of the ankle and tarsus is less frequent than tuberculosis of the spine, hip and knee but more frequent than involvement of the joints of the upper extremities. Synovial thickening is marked, abscess formation with subsequent sinuses frequently occurs. Roentgenograms show destructive lesions of the bone with loss of joint space. The diagnosis is verified by means of culture and guinea pig inoculation of aspirated material. Treatment consists of prolonged immobilization in a plaster cast or brace and operative ankylosis. In rare cases amputation is indicated. Ankylosis with the foot in good position is the most desirable result.

### TUBERCULOSIS OF THE SHOULDER

Tuberculosis of the shoulder may be the dry (cries sicca) or the moist type. The disability is great because of the usual adducted position of the humerus. Diagnosis is established by means of clinical examination, the characteristic changes revealed by roentgenogram and aspiration or biopsy. Treatment consists of promoting ankylosis with the humerus in a position of 60 degree abduction.

### TUBERCULOSIS OF THE ELBOW

A tuberculous elbow bears the best prognosis of any joint for healing with some useful degree of motion. Fixation at right angles with plaster or a splint is indicated. Operative fixation should be carried out in resistant cases.

### TUBERCULOSIS OF THE WRIST

Tuberculosis of the wrist may be primary in the wrist joint or secondary to disease of the carpus or metacarpals. The disease spreads rapidly to the carpal joints and adjacent soft structures, and the disability is great. Prolonged fixation with the hand in 30 degree extension is indicated. Excision of the carpal bones gives favorable results.

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## STATIC DEFORMITIES OF THE SPINE

As in other parts of the skeleton there is a group of deformities of the spine generally known as static deformities, i. e. developing under the influence of weight bearing. To these belong a large part of the anteroposterior deviations or kypholordoses and of the lateral curvatures of the spine or scolioses. All one can say to justify the term 'static' is that gravitational stresses play a major part; it cannot be the sole nor the ultimate cause of the defect, since gravitational stresses are universal while the response of the spine to these stresses by assuming a deformity is exceptional and hence pathologic.

The mechanical function of the spine is that of (1) a sustaining rod maintaining the upright position and carrying its weight, (2) a point of anchorage for the powerful muscles of the shoulder and pelvic girdle as well as of the trunk, (3) a buffer spring receiving and distributing in rapid and endless sequence innumerable jars and jolts associated with the dynamic function of the body, (4) a casing of safety for the delicate nervous structure within the spinal canal and for the peripheral nerves issuing therefrom and (5) an organ of great flexibility subservient to the motor functions of the whole body.

In any of these mechanical functions or in any combination of them the spine may fail because of some underlying local or general causes. Failing as a sustaining rod from weakness or insufficiency of the musculature which supports it and which controls its position it will assume an anteroposterior or lateral curve. Failing as a buffer spring in its function of weight distribution it will cause secondary changes in the bodies and disks which often result in the total loss of the elasticity and of much of the flexibility of the spine. Failing as a safe casing for the nervous structures it will cause irritation or suppression of motor and sensory impulses and finally failing in its flexibility it must necessarily detract from the motor function of the entire body.

What causes these various functions to fail singly or in combination? It is most important for the management of the patient to establish the underlying condition leading to the functional failure of the spine. There are of course definitely localized pathologic lesions which lead to spinal deformities, tuberculosis of the vertebrae, osteomyelitis, trauma and malignant growths. But the group under consideration in this chapter is the one in which the spinal deformities are assumed to be due to a general cause. Herefore it was necessary to be satisfied with such meaningless terms as "habitual insufficiency" but with a better understanding the underlying causes become more tangible and there are being recognized such conditions as constitutional hypoplasias, early or late rickets, developmental growth disturbances, regressive and degenerative changes of the vertebrae and disks, myasthenia and paralytic factors, etc., as underlying reasons

for the mechanical failure and the subsequent deformities of the spine

### THE ANTERIOPOSTERIOR SPINAL DEFORMITIES KYPHOSIS (HUMP BACK) LORDOSIS (SWAY BACK) AND THEIR COMBINATIONS

**The So Called Static Malposture—**  
*Definition*—When is posture abnormal? Posture must be defined in terms of the relationship of the line of gravity to the landmarks of the human body and not as is commonly done by the relationship of the body parts among themselves. In a normal upright stance the line of gravity rising up

diaphragm being most favorably balanced for respiratory function the narrow back or carnivorous type (the slender anatomical type of Willis) with a long narrow chest a small costal angle and a tall slender long body often with high palate and hypertrophied tonsillar and adenoid tissue and the broad back or herbivorous type (heavy anatomical type of Willis) with a large heavy skeleton a wide costal angle a high diaphragm heavy flat and broad vertebrae a short lumbar region a broad and deep abdominal cavity in contrast to the former group the fifth lumbar vertebra is situated low between the ilia the sacrum is more per

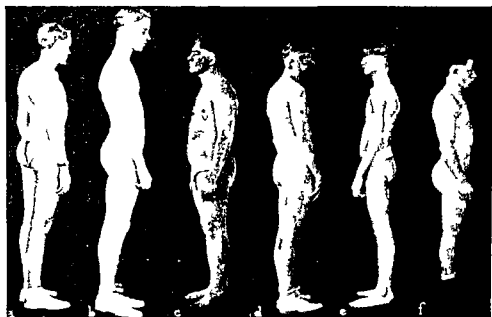


Fig 210—Anatomical types of back. *a* Normal type with moderately rounded thorax *b* slender type of Willis *c* heavy type of Willis *d* round hollow back from normal type *e* flat back *f* round hollow back, heavy anatomical type

in front of the ankle joint and close to the knee joint axis intersects with the spine at the lumbodorsal and cervicodorsal levels to reach the mastoid process. In abnormal posture or malposture this relationship is changed and the line of gravity is deflected usually behind sometimes in front of the normal points of intersection there is a radical change of the gravitational stresses throughout the body and hence also a complete rearrangement of muscular and ligamentous resistance against gravity.

**Classification**—Goldthwaite distinguishes three anatomical types the normal type with moderately rounded thorax and high

pendicular and the mobility of the lumbar spine is rather restricted (Fig 212 *a b c*).

**Types of Malposture**—1 From the normal type develops the round upper and the round hollow back. The former represents a relaxed position the shoulders dragging downward and forward and the pelvis becoming more horizontal; *e* the angle of inclination is lessened. The line of gravity is shifted backward. In the round hollow back the kyphosis of the upper trunk is recovered by a compensatory lordosis so that the line of gravity is little deflected. This type therefore approaches physiologic limits (Fig 212 *d*).

b The slender anatomical type produces the flat back, the body is carried backward by hyperextension in the lumbar region making a sharp curve at the lumbo sacral level. The line of gravity is deflected strongly backward, in the round back of this type there is a total posterior curve with the cervical spine in strong hyperextension to bring the head into the line of vision. The pelvis is horizontal the hips are hyperextended and the line of gravity shows less backward deflection (Fig 212 c)

c In the heavy anatomical type there also develops a round hollow back as in the normal type with increased dorsal kyphosis and lumbar lordosis but the pelvis retains its normal position (Fig 212 f)

**Malposture and Visceroptosis**—Here one deals primarily with a disturbance of the thoracic and abdominal balance due to the weakness and relaxation of the muscles of the abdominal wall and of the pelvic floor. In necessary sequence a malposture develops in which the upper portion of the trunk is thrown backward. Vice versa postural anomalies acquired in youth are very apt to predispose to visceroptosis. Statistics show that in children the incidence of visceroptosis with malposture is great.

**Rachitic Kyphosis**—This condition is the remainder of the physiologic anteroposterior curve of the newborn but because of the weakness and relaxation of the muscles of the back and the softness of the bones the erection of the spine is not accomplished. When a child stands up an attempt is made to compensate the low dorsal rachitic curve by low lumbar lordosis so that the typical malposture is that of a round back or round hollow back.

The nature of the deformity is revealed by rachitic stigmas. The thorax is compressed from side to side so that the anteroposterior diameter of the chest exceeds the lateral one (Treiberg). Owing to the long continued forward flexion at an early age there are marked secondary rachitic changes of the thorax most frequently pectus excavatum or funnel chest, then the sternum is depressed the lower ribs flare out and in the lower thoracic region the lateral diameter exceeds the anteroposterior (Fig 213 a)

**Malposture in Osteochondritis Deformans Vertebrae**—It was believed that this

condition is due to a definite disturbance in the ossification process of the vertebral epiphyses or vertebral epiphysitis (Delahave Schuermann), which becomes apparent about the twelfth year of life. Schmorl's investigations and those of his pupils and followers however indicate that the disturbance in the growth and form of the vertebral body is due rather to changed relations between the body and the intervertebral disk the nucleus pulposus often herniating in small nodules into the softened vertebral spongy substance (Schmorl's



Fig 213.—a Rachitic kyphosis b malposture in osteochondritis deformans

nodules). The result is an anteroposterior kyphosis as an expression of an exaggerated physiologic curve and the vertebrae become more or less wedge shaped (Fig 213 b)

Calve described a localized affection of disturbed enchondral ossification of the body and the latter appears fragmented and its outlines blurred. It is followed by a process of reparation and ends up in a wedge shaped deformation of one or two vertebrae. This condition is observed at a much earlier age.

The clinical symptoms of osteochondritis vertebrae are fatigue backache pain in the limbs and tenderness of the spinous processes over the involved vertebrae. In the earlier form there are sometimes night cries and muscle spasms.

**Treatment of Anteroposterior Deformities—General**—The primary objective of general treatment is to improve the underlying constitutional condition. This is car-



Fig. 214—After operative treatment

ried out by such local measures as removal of the tonsils and adenoids so as to develop free upper air passages and an efficient respiratory function and by a general hygienic regime including recommendations for an

shoulder girdle by appropriate exercises (Lovett). They are taken both in a standing position and lying down.

In the correction of deformity exercises play an important role in developing and maintaining the muscular tone which is a safeguard against progression especially when a noticeable degree of visceroptosis accompanies malposture. Such special thoracic and abdominal exercises are of greatest value. The beneficial effect of this type of gymnastics is likewise very evident in patients with rachitic malposture and is less so in those with a paralytic or arthritic background.

**Correction**—For the actual correction of the already developed deformity exercises and massages important as they are are usually not sufficient. In more severe cases the question of more forcible correction by corrective casts must be considered. To what extent is this possible? This is a question which must be answered with due regard for the type of the deformity, the rigidity of the curve, its duration and the age of the patient. The single curve in the flat and round back is more amenable to gradual correction by means of a cast than the double curves of the round hollow back where improvement is more apparent and usually due to the development of counter curves. Telson's



Fig. 215—Spring back body braces

open air life, tonics and an adequate diet in order to rule the constitutional resistance.

**Prophylaxis**—The prophylaxis of the deformity is based principally on muscle development especially of the back and

technic follows this point by first abolishing the lumbar lordosis in a cast put on in strong forward flexion, then the dorsal kyphosis is corrected by bending the trunk backward over the upper edge of the cast. Naturally

children under six or eight years of age with a more flexible curve usually rachitic are better subjects. In the prepubertal age especially in the osteochondritic type of mal posture, it must be remembered that because of its anatomical change the deformity "sets" rather early, and by the time the age of fourteen or sixteen years is reached real anatomical correction is very difficult (Fig 214)

*Symptomatic*—Supports must be worn such as reinforced corsets with shoulder straps in milder cases or steel braces in more severe cases during the period of muscle development and after corrective cast treatment until the period of convalescence. The reasons for this treatment are twofold. First the subjective symptoms of fatigue and back pain demand special support, second the development of muscle tone so important in the treatment must not be jeopardized by leaving the trunk muscles without safeguard during the critical period (Fig 215)

#### THE LATERAL DEFORMITIES OF THE SPINE SCOLIOSIS

When under certain conditions the normal equilibrium of the spine becomes lost so that it is no longer under active muscle control and has lost its ability to revert to symmetry promptly from any asymmetrical position, the spinal condition must be considered as being pathologic and as undergoing deformation. The deforming process is beyond voluntary control and is progressive being halted only from time to time by the resistance of the tissues—bones ligaments and muscles. In the lateral deformities of the spine the same as in the anteroposterior a number of different underlying causes may be at work which are responsible for the normal loss of muscular control of spinal symmetry and which lead to permanent lateral deviation or scoliosis.

*Types*—A number of these causes are due to congenital defects in the architecture of the spine, in others muscle control is lost by paralysis of the spinal muscles in a third group general metabolic changes which involve muscles and bones are at fault (rachitic scoliosis), and finally as in the anteroposterior deformity, there is also the group of constitutional causes the so called habitual

scoliosis to which no definite tangible factor has so far been assigned. This forms a large group simply because in so many cases one is not able to recognize the etiological factor beyond the vague assumption of a constitutional deficiency.

*Congenital Scoliosis*—The morphological anomalies are principally the wedge formation the rudimentary development of single vertebrae the clefts of the arches (the so called spina bifida occulta or manifesta) or other architectural displacements of the spine. Although the morphological anomalies are scattered over the whole length of the spine the fifth lumbar vertebra is a favorite point and a most effective one in the production of congenital scoliosis since it joins the free spine to the rigid pelvic girdle. Similarly anomalies of the cervical and upper dorsal spine produce scoliosis which often cause asymmetry in the shoulder girdle for instance elevation of the scapula (Fig 216 a)

*Rachitic Scoliosis*—One may distinguish three types (1) a lumbodorsal or lumbokyphoscoliotic form the direct sequence of the usual low dorsal or lumbodorsal anteroposterior rachitic curve (2) a combined type localized in the (more often right) lumbar region and associated with an opposite high dorsal curve and (3) the high cervicodorsal type. The last one is the most characteristic though not the most frequent of all rachitic curves (Fig 216 b)

*Paralytic scoliosis* is a sequela of infantile paralysis and should be anticipated wherever there is extensive paralysis of either the upper or the lower extremities. It follows no particular type since it depends entirely on the distribution of paralysis.

Bilateral symmetrical paralysis of the musculature of the back usually leads to simple lordosis while symmetrical paralysis of the abdominal muscles usually causes the round hollow or round back type of anteroposterior deformity.

In unilateral symmetrical paralysis of the muscles of the back a lumbodorsal or dorsal curve develops in the spine the convexity as a rule pointing to the sound side.

In paralysis of the upper extremity and shoulder girdle a scoliosis develops in the high dorsal region after an interval of latency. If the deltoid and biceps muscles

are paralyzed the effort of the patient to abduct the arm by side bending will facilitate the development of a scoliosis with convexity to the affected side especially if there is also paralysis of the anterior serratus so that the shoulder blade is pulled up by the unopposed action of the trapezius muscle (Fig 217 a)

*So Called Habitual Scoliosis or Idiopathic Scoliosis*—This term merely indicates the absence of a definite underlying cause. It implies a general or constitutional predisposition such as anatomical build and general habitus or inherited or acquired weak-

*Unusual Forms of Scoliosis*—1 The hysterical type is a true contracture a pure inclination deformity and not a true scoliosis characterized by a total curve with the apex at the lumbodorsal junction

2 The so called sciatic scoliosis due to involvement of the sciatic nerve is likewise not a true scoliosis but an involuntary postural inclination due to muscular contracture following back injuries with sciatic radiation

In neither of these types is there a rotation element hence they cannot be classified as true structural scolioses

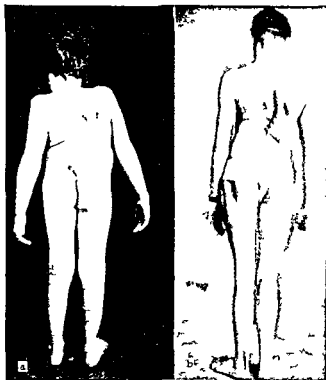


Fig 916—*a* Congenital scoliosis *b* rachitic scoliosis

ness or relaxation of the spine and its musculature. Insufficiency of the spine is another term which is frequently used but it has no meaning and no concrete tangible pathologic factor has as yet been assigned definitely as the cause of this type of scoliosis. Recent investigations as to the role of the intervertebral disk are likely to throw some light on the pathogenesis of this condition. There are usually two types: the right dorsal with a secondary lumbar curve and the left total type of scoliosis. The majority of cases occur in females (Fig 217 b)

3 The so called static scoliosis is the result of inequality of the legs. It is likewise merely an inclination deformity of the lumbar spine. The mobility of the spine is retained and there is no rotation for a long time yet a true structural scoliosis may ultimately develop from it.

4 Scolioses are observed occasionally in spastic paralysis and in tumors of the spinal cord. These are also contractural forms and there is lack of rotation.

5 The scoliosis in tabetic arthropathy of the spine is a true collapse deformity. So

also that seen in the osteoporosis of the spine or in severe osteoarthritis in persons of advanced age

6 In emphysema again a lateral curvature of the spine is often observed which is a simple contracture caused passively by the pull of the emphysematic scar accordingly it shows no rotation

7 *So Called Traumatic Scoliosis*—Of greater interest is scoliosis following trauma In the majority of these cases there have been crushes or fractures of smaller portions of the vertebral bodies and their processes In the dorsal region it often follows a compression fracture of the sixth to the ninth vertebrae In the lumbar region most cases of traumatic scoliosis are due to fractures of the fifth lumbar vertebra Post-traumatic effects on the disk are often expressed by degeneration and shrinkage and these may lead to the habitual assuming of an asymmetrical position and to harelip or other deformity

**Pathology**—Scoliosis is a combination of lateral deformity and longitudinal rotation Both factors are inherent and indispensable parts of the deformity The lateral deviation is brought about primarily either by an inclination of the vertebrae against each other, as in the paralytic type of scoliosis or by a side shifting of the bodies against each other as in rachitic and senescent scoliosis The first mechanism is called the *rotatory* and the second the *collapse* type The first is characterized by a wedge deformation of the vertebral body with the basis toward the convexity, the second by an oblong trapezoid deformation the so called *lique* vertebra Later both types become so closely interrelated as to present one vertebral deformity

The rotatory element of deformity is always present taking place both in the intervertebral articulation *i e* from vertebra to vertebra and within the structure of the vertebra itself This structural rotation is often called *torsion* Both rotation proper and torsion constitute the rotatory deformity

It is not only the vertebral bodies but also the neural arch with the transverse articular and spinous process which take part in the rotation deformity, they are kinked against the vertebral bodies the angle open-

ing on the concave side of the curve, the intervertebral foramen becomes egg shaped with the small pole also to the concave side the pedicle and arch are thinned out toward the convex surface and shortened and thickened toward the concave surface

The most striking rotation effect is seen in the thorax As a result of the backward rotation of the body and transverse process on the convex side the rib on that side is curled against the body and process and becomes sharply bent while on the concave side it appears to be stretched away from

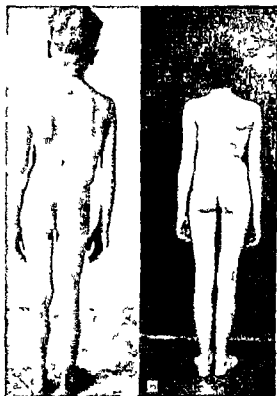


Fig 217—*a* Paralytic scoliosis *b* lateral rotation.

the vertebrae and flattened out This produces in the back the characteristic costal projection or hump on the convex side and the hollow and flatness on the concave side In front conversely, the flat concave side rib projects sharply lateral to the sternum while the buckled convex side rib appears flat so that the projections in front are reversed In the deformation of the thorax the spinal column leads and the ribs follow however the ribs are not being deformed by the twist of the spine alone but also by other mechanical factors the most important of which is the side pressure of the



muscles of the thoracic cage and of the abdominal walls

**Prophylaxis**—When the scoliotic deformity is developed with the marks of lateral and rotation deformity and of permanent loss of symmetry of the spine it is with very few exceptions too late to expect complete anatomical restoration. Hence the most important aspect of the management of the condition is prophylaxis.

How is scoliosis to be anticipated and prevented? In the congenital type one cannot properly speak of a prescoliotic stage yet there is a long period of latency during which the spine is able to maintain its equilibrium in spite of congenital architectural defects. The deficiency is first indicated by occasional postural anomalies and asymmetries and it can at this stage be recognized and held in check at least for a time by systematic muscle training.

In the rachitic type prophylaxis is important. The prescoliotic stage also appears in the form of attitudinal anomalies which however are rather characteristic antero-posterior curves and signify not so much muscular insufficiency as relaxation of the costovertebral junctions and of the intervertebral articulations.

So called habitual or idiopathic scoliosis has always received considerable attention from the viewpoint of prophylaxis. It has been called school scoliosis because it is believed to develop during the school age; some investigators have found as high as 20 or 30 per cent of all school children afflicted with this functional scoliosis as a result of faulty posture. However the usual prophylactic measures are as a rule belated. The critical age is between the third and fifth years and it is at this time that prophylaxis should be practiced.

In paralytic cases it is difficult to speak of prophylaxis. A long silent interval usually exists between the onset of paralysis and the first appearance of scoliosis. One should be prepared for it however in all cases of severe involvement of the extremities. It is very difficult to recognize differences in the muscle strength of both sides of the back. Because of the rapid progression of this type of scoliosis even the slightest suspicion of asymmetry calls for energetic preventive measures.

**Treatment**—Treatment should consist in (1) the correction or improvement of the deformity either by flattening the existing curve itself both in the lateral and rotatory sense or by developing contralateral counter curves above and below the original one which offset the lateral and rotatory deflections of the body (compensation) and (2) the maintaining of any correction or improvement either by a systematic development of the back muscles or by abolishing motion in the intervertebral junctions and by stiffening of the spine.

It is obvious that different patients will respond differently to one or the other of the alternatives by which these two objectives may be advanced. Yet before discussing the methods the following facts should be considered.

a In the great majority of cases the original curve is so resistant that attempts at correction either by manipulation casts or redressment so called will result in the development of counter curves until a certain degree of corrective force is reached before which the original curve will give. Such a degree of force is usually intolerable if applied suddenly but gradual transformation of the curve to a certain point can be expected from lesser and tolerable degrees of direct force.

b In part of the cases the correction may be maintained actively by muscle balance; such ability depends primarily on the development and training of the muscular apparatus of the back and on the general distribution of body weight in the trunk or in other words the general alignment. The latter again depends on the sufficiency of secondary contralateral offsetting or compensatory curves established in the neighboring sections of the spine.

In another part of the cases the spine can not be maintained by active muscle balance and the deformity progresses. Here passive support of the spine becomes necessary by means of external or internal splinting. External splinting means braces which are not satisfactory as a permanent solution of the problem. Internal splinting means operative fusion or arthrodesis of the spine. In this all cases must be relegated which cannot be definitely controlled by active muscle balance and inevitably progress in

deformity and in which no general or local contraindications to operation exist. But the fortune of the fused spine likewise depends on its general alignment. Spines which have been "realigned" by development of counter curves hold easier after fusion than spines with marked misalignment or overhang." In the latter fusion often breaks and pseudoarthrosis develops.

The practitioner who is seeking advice on the treatment of scoliosis is likely to meet up with a diversity of opinions among specialists which must be very disconcerting both to him and to his patient. The principal reason for this is because it is so uncertain what the particular case of scoliosis will do in the future if left to its own muscular safeguards, whether or not it will yield to manipulative correction and if so how much, whether or not if such correction is obtained it will become more difficult for the muscles to retain the position of the spine than it had been before.

Everything centers more or less upon the self corrective and self retaining power of the musculature. Thus the surgeon must first of all satisfy himself on these points. First is there a prospect of obtaining a restoration of the general body posture by developing compensatory curves and second is there a prospect of maintaining such recovery of posture by developing and training the muscles of the back in other words by active self correction. This cannot be settled at first glance during the initial examination. With the exception of severe paralytic and severe congenital cases in which we know that it is impossible to obtain active self correction because of lack of muscle material in one case and severe defects in anatomic construction in the other most cases and especially those of the static and habitual group will require careful observation for at least six months before it is decided whether a conservative or an operative program should be followed.

In the light of these viewpoints it is possible to plan a definite program for each patient.

**1 Compensation Derotation Treatment.**—The disalignment of the trunk against the pelvis or the overhang as it is called constitutes a state of decompensation of the spine as a whole. This must be corrected

first because in this state the deformity is progressive and there is no possibility of muscular control. Correction can be obtained only by establishment of adequate counter curves above and below the primary curve and in changing the C shaped curve into an S shaped or triple curve. This is done by passive mobilization together with massage and exercises. When this so called compensation is established or while it is being established attempts are also made to flatten the curves or eventually to straighten them out entirely if the degree of rigidity

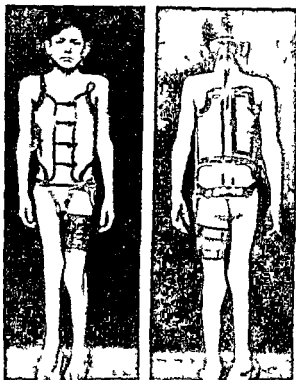


Fig. 218.—Brace used in compensation-derotation treatment.

permits. This is done by adding to the passive correction of the curve by side bending the so called derotation of the curves especially of the lumbar portion of the spine. This again is done by passive rotation of this portion of the spine through the pelvis. The muscle development must always keep step with the relaxation of the spine; otherwise muscle control will be lost and the spine will collapse. A brace is worn between treatments to preserve muscle tone and to prevent fatigue.

This compensation-derotation treatment suffices in itself in a certain number of cases

namely cases of light or moderate habitual scoliosis and mild rachitis but in only a few of the congenital and practically none of the paralytic type

2 When it appears that results cannot be obtained by the compensation derotation method one must use more forcible means of correction with corrective casts applied in certain positions and in graduated steps. Two methods are to be recommended that of Galeazzi and that of Risser. Galeazzi's is a corrective cast applied in a forward bent position with contralateral bending and rotation of the shoulder girdle and the sacro-lumbar portions of the spine. Its primary

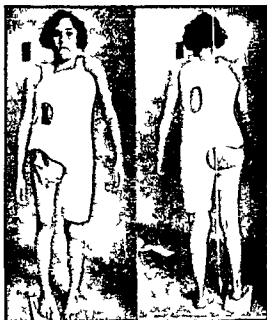


Fig 210—Corrective cast in treatment of scoliosis front and back views

effect is in the sense of compensation curves leading according to the degree of rigidity to complete correction (conversion) of the primary curves in some cases. The Risser corrective cast is applied in a recumbent position and by means of a turn buckle arrangement one gradually obtains satisfactory compensation curves and in some few cases actual correction of the primary curve. All cases in which satisfactory compensation cannot be obtained by the so called compensation method should undergo cast correction. These include the more severe cases of the habitual type the more severe rachitic scolioses the older congenital deformities and late cases of paralysis which have progressed to marked structural deformity.

3 When it appears that compensatory correction by counter curves can be satisfactorily obtained by one of the methods previously mentioned but that correction cannot be maintained by active muscle balance that the spine is unstable and that progression of the deformity is therefore imminent it then becomes necessary to secure the spine by arthrodesis or a fusion operation provided there is no contraindication of a general nature to operative intervention. This type of correction is necessary in the majority of cases of paralytic and of congenital scoliosis and the more severe forms of the rachitic and habitual types. However there are a great number of exceptions some patients especially those with severe paralysis are poor operative risks in others the operative intervention may be balked by great technical difficulties for instance in cases of high cervicodorsal rachitic scoliosis. The operation of choice is a combination of the Hibbs and Albee procedure used in tuberculosis of the spine the fusion by bone bridges and chips and reaming out of intervertebral articulations is further supported by longitudinal tibial or rib grafts placed on the arches into the concavity of the curve.

4 When it appears that neither correction nor improvement can be obtained to any acceptable degree by means of compensation curves and that the spine cannot maintain itself by active muscle force in whatever condition it may be either the patient should be placed in a brace for an indefinite time certainly until he attains full growth or an operation should be performed. In the latter case however the outlook for maintaining the spine in its proper position and preventing further collapse is not altogether certain as in many cases pseudarthrosis develops in the fused areas especially in the lumbodorsal region under the stress of the overhang of the body. As a rule the greater the general disalignment of the body the poorer the chance that the fusion will hold. The most severe and intractable forms of scoliosis of all types unfortunately a considerable percentage of all cases of scoliosis when they come under the physician's observation belong to this group.

This short outline of the treatment serves to emphasize the all importance of the earliest possible recognition and timely pro-

physiaxis of scoliosis. Until these vital facts have become generally appreciated there is not likely to be any real progress in the management of cases of scoliosis.

A STEINDLER

## ACUTE SUPPURATIVE ARTHRITIS

(Septic Arthritis Pyogenic Arthritis Pyemia of Joints Pyarthrosis)

**Etiology.**—Acute suppurative arthritis is an infection of a joint cavity and its constituent structures by pyogenic organisms. These organisms as a rule are either *Staphylococcus aureus* or one of the more common pathogenic streptococci; occasionally they are pneumococci, meningococci or other organisms.

In many instances a primary focus is not demonstrable but it is assumed that the tonsils or some other similar focus is the source. As a rule however the organism is carried in the blood stream to the joint from some region of acute infection elsewhere. In many cases this focus is a furuncle, a region of cellulitis or an ulcer. Meningococcal arthritis and pneumococcal arthritis as a rule occur in the course of diseases caused by *Neisseria intracellularis* (the cause of epidemic meningitis) or the *Diplococcus pneumoniae*. There are however isolated cases of pneumococcal arthritis not associated with pneumonia and reports have been made of cases in which meningococcal arthritis preceded the onset of definite epidemic meningitis. Any organism capable of causing infection in the human body may at times cause suppurative arthritis. This type of arthritis is a frequent complication in the course of septicaemia and of acute bacteremia of various sorts.

There are cases in which direct extension takes place into a joint from a neighboring focus of infection such as a furuncle or a region of cellulitis near the knee joint. When wounds involve joints or when compound fractures occur joints may be invaded by infecting micro-organisms. Osteomyelitis particularly epiphysitis often may be complicated by suppurative arthritis.

**Pathology.**—The extent of the pathologic change depends on several factors: (1) the virulence of the causative micro-organism

(2) the resistance of the patient to that micro-organism and (3) the amount of pre-existing injury to a joint either by mechanical forces or disease before infection takes place.

Phemister demonstrated that cartilage may be rapidly destroyed when incubated in pus from pyogenic abscesses. The gross appearance of the cartilage when infection has developed in a joint varies somewhat with the stage and the severity of the infection. However fairly early the cartilage becomes almost the consistency of jelly, loses its pearly translucence and becomes opaque. In more severe cases it may be almost completely destroyed within two or three days. In less severe infections the process is much slower. Softening of the cartilage is of the greatest importance in determining the restoration of function. With softening of the cartilage begins the actual invasion of the substance of the cartilage by polymorphonuclear neutrophils and by the various cells engaged in repair following infections. With healing a scar tissue type of replacement takes place so that fibrocartilage is present in place of hyaline cartilage.

The pathologic changes in the synovial membrane are similar to those seen in any serous membrane that is exudation with clotting of fibrin on the surface of the membrane. The pouring out of polymorphonuclear leukocytes into the joint and into the membrane itself and the appearance of the usual elements of inflammatory tissue reaction follow.

The capsule is not involved in many cases. When it does become involved destruction of the capsule takes place with slow repair as in any ligamentous infection.

The bone adjacent to the joint may become involved and probably does become involved in all cases of severe infection of a joint. The intertrabecular spaces in the cancellous bone become filled with polymorphonuclear leukocytes and in the more severe cases actual necrotic portions may appear with subsequent sequestration and extension. In cases of acute epiphysitis with involvement of joints the entire epiphysis often becomes necrotic and eventually forms a sequestrum which must be removed.

**Symptoms and Diagnosis.**—The most common symptom of acute suppurative ar-

thrits is pain in the region of the involved joint. At first this pain may be noticed only on motion of the joint but as the disease progresses the pain becomes more severe and as the capsule of the joint is distended pain may be constant and usually is very severe. With the advance of symptoms any movement becomes exceedingly painful. Associated with pain is a limitation of movement and muscular spasm. Swelling usually follows and advances fairly rapidly until the capsule of the joint is fully distended. Redness may appear on the surface of the skin although in the deeper joints such as the hip joint this is by no means a constant symptom.

Besides the localized symptoms general reactions of more or less severity are usually seen. There is usually a general febrile reaction varying from slight to very severe. Malaise, chills, sweating and the other symptoms usually associated with febrile reaction may be noted.

The diagnosis of acute suppurative arthritis is in most instances fairly easy to make. Most of the joints of the body (the hip is a notable exception) are sufficiently superficial so that the localizing symptoms and signs are fairly easily detected and as a rule are easily recognized.

In diagnosing any case of acute suppurative arthritis one may expect to find swelling which obliterates the normal contours of the joint, increased local temperature, *increased fluid in the joint or thickening of the lining of the joint*. It is important to determine the presence of fluid. Muscular spasm causing limited movement is always present to some degree. There may be redness of the overlying skin, particularly in cases in which cellulitis exists. Deformity is usually present and is caused by the muscular spasm which holds the joint in a deformed position. Usually this position is the one of greatest comfort and is different for each joint. A leukocyte count is important. In suppurative arthritis the number will be elevated and the percentage of polymorphonuclear leukocytes will be definitely increased. From 10,000 to 90,000 leukocytes per cubic millimeter of blood are commonly found and much higher counts are often made. The other important diagnostic test is aspiration of the joint with removal of some of the fluid. A

culture of this fluid should always be made in order to determine the causative agent. With this point settled one often can decide on the course of treatment and may be able to predict the outcome more accurately than without this information.

Acute suppurative arthritis may be confused with several other conditions. One of these conditions is osteomyelitis involving the diaphyseal ends of bones; another is epiphysitis. Confusion is particularly likely to occur in those cases in which the infection lies so close to the joint that effusion takes place within it because of the irritation of the synovial membrane, but without actual bacterial invasion. Acute suppurative arthritis in its early stages may be confused with post-traumatic or infectious acute synovitis that is confined to one joint. In cases in which there is any uncertainty between these two diagnoses aspiration and examination of the joint fluid with culture if necessary will supply the necessary information. Hemarthrosis either as a result of trauma or as a postoperative complication may be very confusing at times. A hematoma often causes a sharp elevation of temperature but again the final diagnosis can be made by aspiration. Chronic infectious arthritis rarely is confused with acute suppurative arthritis. Rheumatic fever is sometimes difficult at first to distinguish from acute suppurative arthritis but the course of the two diseases is entirely different. Rheumatic fever spreads from joint to joint and there is no residual change in the joints. Occasionally bursitis, particularly very acute bursitis with marked swelling and pain may be difficult to distinguish from acute suppurative arthritis. As has already been indicated the signs of involvement of the hip are not so easily detected and a wide variety of conditions including osteomyelitis of the pelvis must be distinguished from acute suppurative arthritis of the hip. A pelvic or peroneal abscess with resulting flexion of the hip and occasionally appendiceal and renal infections may produce confusing pictures.

**Prognosis.**—The prognosis in acute suppurative arthritis is variable. Formerly in the more severe fulminating types of infection particularly those accompanying septicemia the danger to life was great. With the improved methods of chemotherapy the

danger to life has been greatly reduced. Without modern chemotherapy the condition must be regarded as serious in many cases some articular function is lost as a result of the disease. If function is severely impaired and slight pain persists on motion it is to be hoped that complete ankylosis eventually will result because this produces a stable useful limb provided ankylosis has been produced with the joint in the position of election. Following less severe types of infection normal function usually is restored.

**Treatment**—Treatment today should start with the use of penicillin if available. Reports from all available sources indicate that if organisms sensitive to penicillin therapy are the causative agents good results will be obtained by the use of penicillin. Details as to administration of penicillin are not given here as they are available elsewhere in the volume. Lyons noted that suppurative arthritis responds dramatically. Penicillin may be injected directly into the joint or may be administered intravenously or intramuscularly. Dawson and Hobby suggested the injection of 10 000 units daily into the joint for three days.

If penicillin is not available sulfonamides may be used during the acute stages. One may inject an 0.8 per cent solution of sulfanilamide into a joint but it is not recommended that other types of sulfonamides be injected into a joint. Usually one depends on the oral administration alone. In cases in which chemotherapy has not been employed or in which the response to this type of therapy has been unsatisfactory surgical intervention is indicated if after several days illness a joint cavity is distended with purulent material. The type of drainage and the situations of incisions for drainage vary somewhat (Fig. 220). In general it may be said that incisions into joints should be made in the area where the joint lies closest to the skin. Usually in such areas the capsule is weakest and distention with fluid will be localized there. Thus in the knee joint the lateral pockets of the subquadriceps pouch will be the fullest and most easily drained. The same is true of the elbow where fullness will be detected on either side of the olecranon. In the ankle one of the following areas is most frequently used for approaching the joint: the region anterior to the fib-

ula the area between the anterior tibial tendon and the internal malleolus or the area posterior to the peroneal tendons. At the shoulder one finds a bulge posteriorly through the thinner portion of the deltoid muscle or between the deltoid and scapular border. The joint may be approached through this bulge or through an anterior incision splitting the deltoid muscle. The hip joint presents a different problem for it is more deeply placed. Many surgeons advocate the use of an anterior incision medial to the tensor fasciae femoris and lateral to the rectus femoris and sartorius. In most cases of acute suppurative arthritis of the hip joint however I believe a more satisfactory type of drainage will be obtained through Ober's incision—the fibers of the gluteus maximus muscle are split longitudinally and the subgluteal fat is opened. The surgeon should watch for the sciatic nerve at the medial angle of the wound should separate the gemelli inferior from the tendon of the obturator internus and should open the capsule of the joint by a crucial incision.

Once the incision into the capsule of the joint is made treatment varies somewhat with different surgeons. The majority agree that thorough lavage of the joint either with physiologic saline solution or with a mild antiseptic solution of some sort is best. Some believe that as soon as lavage is completed the joint may be closed. In general however the joint should be left open to allow free drainage. Drains should not be allowed to penetrate a joint if it is hoped to preserve the function of the joint and this applies particularly to counter drainage or to through and through drainage. Usually a drain introduced down to the joint and made either of rubber tissue or petrolatum gauze gives the best results. Fixation of some sort is necessary in these cases for the inflamed surfaces of the joint will be kept activated if motion is not prevented for a few hours or a few days at least. Usually the best support for the various joints is furnished by the following devices: a molded plaster splint or a Thomas splint with Pearson attachment for the knee; Buck's extension for the hip; a right angled metal splint for the ankle; a cock up splint for the wrist; a right angled splint for the elbow and an aeroplane splint for the shoulder.

Jones wrote "It is necessary to rest an arthritic joint until pain and inflammation have disappeared. Movements when commenced should be active not passive. Active movement will be limited by pain to an excursion that does not injure the delicate membranes of the inflamed joint. At the same time active movements develop the atrophied muscles a factor of greatest importance to the recovery of the normal function of a joint. Weight bearing must not be commenced until the softened joint cartilage has been restored to more or less normal

extreme cases with extensive destruction of joints and with no improvement under proper care amputation is indicated sometimes as a life saving measure and at other times as a measure of economy.

#### GNORRHEAL (NEISSERIAN) ARTHRITIS

**Etiology and Pathology**—Gonorrheal arthritis one of the complications most feared in cases of gonorrhea is in many respects similar to acute suppurative arthritis. It is a severe infection often polyarticular at first and later localizing in one joint. It is

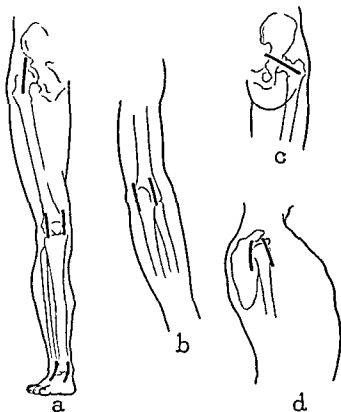


Fig. 220.—a Lines of incision on the ankle, knee and anterior aspect of the leg; b Lines of incision on the elbow and shoulder; c Posterior incision for drainage of the leg; d Lines of incision for drainage of the shoulder.

consistency a process which takes weeks rather than days. Again the severity of the symptoms must be accepted as a guide. In the event of very severe infection of several days duration in which it seems that ankylosis must result the surgeon should see to it that ankylosis in the most favorable position for whichever joint is involved is promoted.

After drainage is established one should continue chemotherapy until the patient is afebrile and evidence of subsidence of the local infection is clearly demonstrated. In

due to the Neisseria gonorrhoeae. In its pathology it is not unlike acute suppurative arthritis. Essentially the same sort of changes will be found in all the component parts of the joint. In the more severe cases injury to bone may not be so severe as in the extreme cases of pyogenic arthritis. The same rapid destruction of cartilage takes place in these cases however and the same severe synovial tissue reaction.

The incidence of gonorrheal arthritis as a complication of gonorrhea has been greatly reduced since the advent of

chemotherapy, and with penicillin therapy this complication apparently will be further reduced if not completely eradicated in cases in which gonorrheal urethritis is treated properly.

The onset almost always follows closely an episode of urethritis. Collings found in a study of 517 cases of gonorrheal arthritis that in 75 per cent of the cases involvement of joints developed within fifteen days of the urethral infection. Thomas found the incidence of arthritis in cases of gonorrheal infection to be between 2 and 3 per cent. The same author found that in 58 per cent of the cases involvement was polyarticular and in 42 per cent monarticular. The joints involved and the number of cases in which they were involved were as follows: knee 58, hip 50, wrist 21, shoulder 19, pharyngeal joints 17, elbow 13, metatarsophalangeal joints 8, spine 8, metacarpophalangeal joints 8, sesamoid joints 1, temporomandibular joint 1 and sternoclavicular joint 1.

Involvement in gonorrheal arthritis is often multiple at first. Several joints may be involved one after another or several may be involved simultaneously in the latter type of case there is pain but very little swelling, redness or limitation of function. However one joint or at times two or more joints become much more severely involved there is marked swelling, severe pain, redness, an increased quantity of fluid in the joint and deformity caused by muscular spasm. In addition to these local symptoms there is usually some general reaction although this is not so marked as a rule as that found in the presence of pyogenic infections.

**Diagnosis.**—The diagnosis in these cases usually is dependent on the discovery of the primary seat of infection. Acute arthritis complicating active gonorrhea is not necessarily gonorrheal arthritis; usually the arthritis is gonorrheal; however it is difficult in many cases to find the organisms in the material aspirated from a joint probably because the organism remains embedded in the synovial membrane. In many cases the organism can be obtained by the use of cultures and identified by means of Gram's stain. Better methods of culture of the gonococcus particularly by the use of chocolate blood agar have demonstrated the presence

of the organism in a much higher percentage of cases. Infrequently, multiple infectious arthritis results from gonorrhea but the diagnosis is presumptive not positive.

In a few cases of gonorrheal arthritis gonorrheal septicemia develops and results fatally. As a rule however gonorrheal arthritis is not fatal. The function of joints often is lost because the swift destruction of the articular cartilage leaves ideal conditions for ankylosis. However if the progress of the infection can be stopped before destruction of the cartilage is complete restoration of the normal function of a joint can be obtained in many cases.

**Treatment.**—The treatment as in all cases of acute arthritis consists of rest and an attempt to eradicate the infection. The presence of gonorrheal arthritis in a case in which apparently adequate chemotherapy has been employed is an indication of failure of chemotherapy probably due to a resistant strain of *Neisseria gonorrhoeae*. In such cases penicillin therapy should be employed. Most of the sulfonamide-resistant types of gonorrheal infection will respond to penicillin. Ever therapy formerly helped in these cases but it need now seem doubtful in view of the apparently good results obtained with penicillin. To insure rest of the affected joints splints of aluminum, steel or plaster of paris may be used. At times pillows will suffice. In the very acute stage the joint may be kept in the position of greatest comfort but if ankylosis apparently will take place every effort should be made to have the joint in the position of maximal function. Wrapping the joint in cotton wool, application of hikers and hot water bag, and the use of oil of wintergreen may add to the patient's comfort. Sedatives in fairly large doses may be necessary.

In combating the infection the first effort to be made is to rid the patient of the primary focus. This will be impossible in some cases but the attempt should be made. Aspiration of the joint relieves tension and often makes the patient more comfortable. Irrigation of the joint is often advisable.

With the subsidence of acute symptoms attention must be given to the restoration of the function of the joint. Active exercises are the most valuable because pain limits their use so that injury will not be caused



by them. At the same time they restore muscular strength. Joints which bear weight should not be used for several weeks or until the cartilaginous surfaces have become fairly well hardened. Function of joints which do not bear weight may be permitted earlier.

If ankylosis is apparently taking place and the original focus has been cleared up, manipulation may be tried after the acute symptoms have subsided. If ankylosis has taken place as a result of gonorrheal arthritis, arthroplasty is the only means of restoring motion. Such joints are usually very favorable for arthroplasty, but one must wait as a rule two years from the time of the original infection before attempting surgical treatment.

### TYPHOIDAL ARTHRITIS

The relative infrequency of typhoid fever in most parts of this country now makes typhoidal arthritis a rarity. However its differential diagnosis in some cases must be considered. Osler wrote that there were 8 cases of typhoidal arthritis in a series of approximately 1500 cases of typhoid fever. Arthritis if it is to occur usually appears between the twenty-ninth and thirty-fifth days of typhoid fever, according to Caussade and Tardieu. Usually it presents the picture of a moderately severe suppurative arthritis and in some cases leads to ankylosis. In other cases the arthritis may be generalized and milder and recovery may supervene. Establishment of a diagnosis of typhoid fever is essential to a diagnosis of typhoidal arthritis and the bacillus should be recovered from the joint. Occasional cases of late typhoidal arthritis are reported. A positive Widal reaction performed on joint fluid is not sufficient evidence to support a diagnosis of typhoidal arthritis for the fluid usually will have the same reaction as the blood serum. Treatment in these cases depends on the severity of the symptoms but in general consists in fixation followed by massage and by exercises in the convalescent stages. Drainage will be necessary only in the most severe cases.

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### PAINFUL AFFECTIONS OF THE LOWER BACK

**Anatomy.**—The joints of the lower back are (1) the articular facets (2) the intervertebral disks and (3) the sacroiliac joints (Figs 291 and 292). The articular facets in the lumbar region face in the anteroposterior or sagittal plane. They are interlocked in such a way as to give freedom in flexion and extension and to allow a minimum amount of rotation. Because of this very limited play in rotation, the lumbar portion of the spine is relatively stable and injuries occur chiefly in the positions of hyperflexion and hyperextension. The articular facets do not always face in the sagittal plane, sometimes being in an oblique and sometimes in a true frontal plane. This is particularly true of the facets between the fifth and first sacral vertebrae. Such an anatomical variation does not in itself give rise to symptoms but results in increased mobility in rotation and therefore predisposes to strain.

There are other anatomical variations which affect the function and stability of the region. The most common of these is the sacralization of the transverse process of the fifth lumbar vertebra (Fig 292). This may be either unilateral or bilateral; if unilateral it is particularly apt to render the function of the lumbosacral junction asymmetrical and therefore predisposes to strain.

Another quite common anatomical variation is spina bifida occulta—a lack of fusion

of the laminae of the neural arch (Fig 223). Such a variation is commonly associated with variations in the articular facets which



Fig 221.—Diagram showing the irregular congruous surfaces of the sacrospinous joint and the articular facets.

render the lumbosacral junction unstable and result in localized symptoms of strain.

Spondylolisthesis or a forward displacement of one vertebra on another occurs

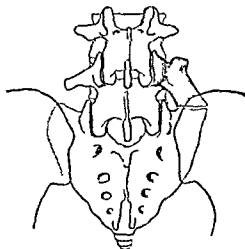


Fig 222.—Lateral sacralization of the transverse process of the fifth lumbar vertebra.

more often at the lumbosacral junction than in any other region. It is commonly associated with a congenital defect in the ped-

icles of the fifth lumbar vertebra which allows the laminae and articular facets to remain in normal relation to the sacrum while the body of the fifth vertebra displaces forward. This condition may be very mild and accompanied only by local pain, or it may be extreme and associated with symptoms due to pressure on the cauda equina.

The intervertebral disks are not true joints but perform the function of joints. They consist of three parts—cartilaginous disks above and below and the nucleus pulposus in the center which is surrounded by a third part, the annulus fibrosus. The structure of this disk is such as to allow compression as well as distraction in any direction.

The sacrospinous joints are true joints consisting of two irregular congruous joint sur-

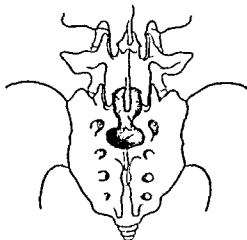


Fig 223.—Bifida occulta.

faces covered by hyaline cartilage; they have a definite synovial membrane. The congruity of these joint surfaces tends to increase their stability (Fig 221), making up to some extent for the relatively inefficient ligamentous and muscular support. The oblique plane of the sacrospinous joints also adds to their stability (Fig 221). Because of this obliquity, muscular leverage rotating the ilium forward on the sacrum tends to put the joint surfaces into better apposition and cannot produce a ligamentous sprain; the iliacus muscle produces such leverage. Leverage rotating the ilium posteriorly on the sacrum tends to unlock the joint and therefore is effective in producing sprains. This type of leverage is produced by the hamstrings. The sacrospinous ligaments (Fig 224) are strong

superiorly, posteriorly and inferiorly; anteriorly, however, they are very weak and consist of a slight thickening of the periosteum.

which must be referred to when a diagnosis of lumbar or lumbosacral strain or sprain is being made (Fig. 225). The active or muscular support is the same for the spinal

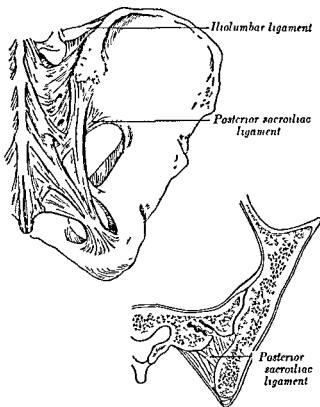


Fig 224—The sacroiliac ligaments and the oblique plane of the sacroiliac joint

The supporting structures of the spinal joints are of two kinds passive (ligamentous) and active (muscular). The chief ligaments of the spine are the supraspinous, in-

and for the sacroiliac joints, since a stable position for the lumbar joints is also a stable position for the sacroiliac joints. The muscular groups that are of particular concern

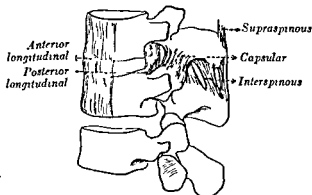


Fig 225—Ligaments of the spine

terspinous, capsular, posterior longitudinal and anterior longitudinal. A clear mental picture of these supporting structures must be secured, since they are the structures

are the (1) erector spinae, (2) abdominal, (3) gluteus maximus, (4) iliopsoas and (5) hamstring muscles.

1. Erectores spinae originate from the dor-

sum of the sacrum and posterior iliac crests and insert into the spine and posterior chest wall (Fig. 226). The function of this group of muscles is to resist gravity when the body is in the erect position and to assist in a return to the erect position from the forward bent position.

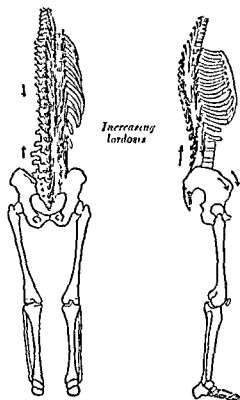


Fig. 226—Erectores spinae, right side

2. The abdominal muscles (Fig. 227) represent extremely important support if normally controlled. When these muscles contract they approximate the pubes to the chest and in so doing tilt the pelvis into a more vertical and more stable position. This is particularly true if they are assisted by the gluteus maximus.

3. The gluteus maximus (Fig. 228) originates from the posterior ilium and lateral border of the sacrum and inserts into the greater trochanter and iliotibial band. When this muscle contracts it rotates the pelvis into a vertical plane. The cooperation of the abdominal muscles with the gluteus maximus constitutes a most important factor in maintaining a correct posture. With the pelvis in the vertical plane, the superior surface of the sacrum tends to become horizontal, and since this surface represents the founda-

tion of the spine, it should approximate the horizontal plane in order that the superstructure may be stable.

4. The iliopsoas muscles (Fig. 229) originate from the vertebral bodies, transverse processes and iliac fossae and insert into the region of the lesser trochanter of the femur. When they contract they approximate these two regions; consequently, if the femur is fixed they will tend to exaggerate the forward curve of the lumbar spine. This is an important point to keep in mind in the correction of faulty posture with an exaggerated lumbar curve; very commonly hyperextension exercises of the hips must be performed in order to stretch these muscles and overcome their vicious pull.

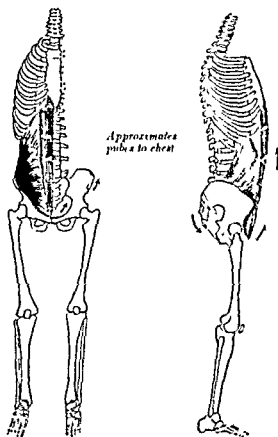


Fig. 227—Abdominal muscles.

5. The hamstring group (Fig. 229) originates from the ischium and inserts into the tibia and fibula. When these muscles contract they approximate these two regions, depressing the ischium and rotating the ilium posteriorly. This is the type of leverage to which the sacroiliac joints are particularly suscep-

tible and tight hamstrings predispose to sacroiliac sprain

**Trauma**—The *analysis of trauma* represents a valuable source of information which is frequently neglected. Injury to the spine—bony, ligamentous or muscular—results either from compression or from stretching

tract they diminish the flexion of the spine the spinous processes are approximated and the posterior ligaments are relaxed. The onset of pain indicative of injury during this act of lifting cannot be accounted for on the basis of a ligamentous sprain since these structures are becoming relaxed. Such pain can be accounted for on the basis of a muscular sprain. The erectores spine are actively contracting against the resistance of gravity and if the load is too heavy a muscular sprain results. Such a sprain practically always takes place at the attachment of the muscles to the periosteum of the sacrum and ilia and results in pain over these regions (Fig 231)

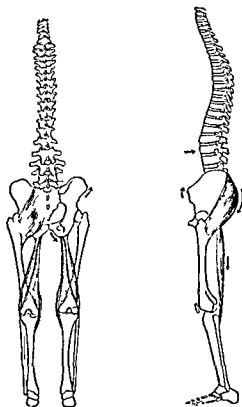


Fig 228—Gluteal muscles and iliac crest

By analysis of the injury the structures exposed to either type of trauma are determined and the examination will consequently be directed toward these and therefore will be more intelligent.

An analysis of an injury resulting from lifting is made as follows. In bending forward to lift an object a complex motion is performed. This consists of flexion of the spine and the tilting forward of the pelvis at the hips. What effect on the supporting structures does this motion have? As the spine becomes flexed the intervertebral disks are compressed anteriorly and the spinous processes are separated. As a result the supraspinous, interspinous and capsular ligaments are put on the stretch and by the tilting of the pelvis the hamstrings become taut (Fig 230). As the load is lifted the erectores spine contract and as they con-

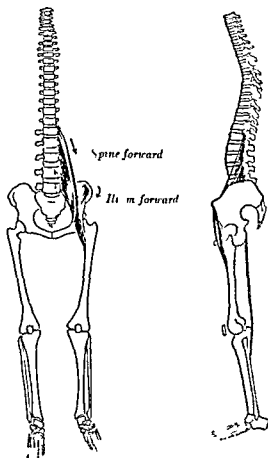


Fig 229—Iliopsoas muscle

A sprain of the sacroiliac ligaments may result from a lifting injury. During the act of lifting the hamstrings with their origin from the ischial tuberosity and their attachment to the tibia and fibula are held taut to prevent the pelvis from tilting further forward consequently the leverage of the ham-

strings tends to rotate the ischium downward and the ilium posteriorly away from the sacrum. Since this is the particular type of leverage to which the sacroiliac joints are

subject it may occur also as an isolated injury from hyperextension or hyperflexion. The nature of the injury is such as to produce rupture of the annulus fibrosus allow-

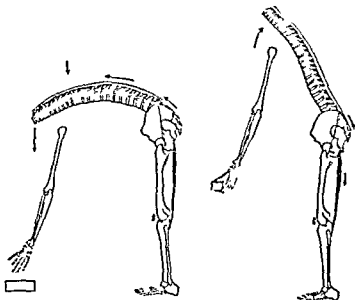


Fig. 230—Analysis of injuries caused by lifting

susceptible a sprain of the sacroiliac ligaments secondary to the disalignment of this joint may result (Fig. 232). Lifting injuries, however, result in the majority of cases in muscular sprain of the erector spinae muscles.

Hyperextension injuries of course bring about an approximation of the spinous processes and the articular facets; consequently there may be a compression injury of the posterior ligaments or fracture of the spinous processes, laminae or articular facets (Fig. 233).

Sacroiliac sprains have been described as resulting from a lifting injury. Any action which involves contraction or tension of the hamstrings tends to rotate the ischium downward and forward and the ilium backward. A unilateral strain of this type is more effective than a bilateral strain and is well illustrated by the driving of a motor car (Fig. 234). Every time the clutch is put out or the brakes applied, especially by a small person with a short reach, the hamstrings are rendered taut and a vicious leverage is applied to the sacroiliac joints. This is a very frequent cause of sacroiliac strain.

Injury to the intervertebral disks may occur secondary to fractures of the vertebral

bodies; it may occur also as an isolated injury from hyperextension or hyperflexion. A ruptured annulus fibrosus sometimes protrudes into

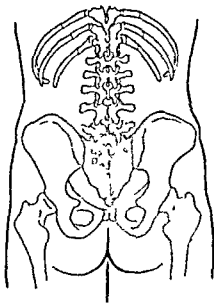


Fig. 231—Diagram showing the distribution of pain due to muscle strain and muscle spasm

the spinal canal producing localized pressure on the spinal nerves at the intervertebral foramina. Because of the tension of the spinal nerve, local and radiation pain results.

This condition has been recognized during the last few years only previous to that other clinical entity. As a matter of fact the clinical picture is difficult to differentiate

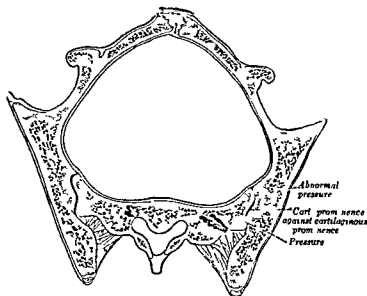


Fig 23<sup>2</sup>—Diagram showing disalignment of the right sacroiliac joint

time operative findings were interpreted variously as indicating chondroma or fib

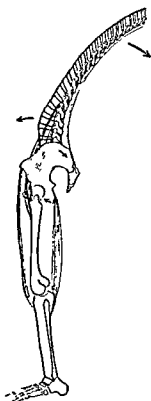


Fig 23<sup>3</sup>—Diagram illustrating injuries caused by hyperextension

roma. The clinical picture presented by this injury is as yet not diagnostic it adds an

etc from that presented by strain or disease of the sacroiliac joint. It is associated with pain referred to the same regions as that due to some condition of the sacroiliac joint and the clinical findings are not such that at present a clear differentiation can be made between the two conditions.

There is no question that as additional work is done a definite amount of knowledge will be gained which will help in the diagnosis of so called mysterious disorders of the back. The recognition of this clinical entity has led to the use of lumbar puncture as a routine in any case of pain in the back not relieved by conservative non-operative methods. In cases of injury to the intervertebral disks the localized irritation causes a rise in the total protein content of the spinal fluid. Unfortunately this rise is sometimes very slight or absent but in most cases it is above what is considered normal. The total protein content should be interpreted with respect to the age of the patient; the younger the patient the lower the total protein content should be.

The main point to be remembered about injuries to intervertebral disks is that they represent a new clinical entity, one that will account for some of the cases in which no diagnosis or an incorrect diagnosis has been made in the past.

**Pain**—It is possible to differentiate between three types of pain resulting from a lesion of the spine or sacroiliac joints: local pain, referred and radiation pain and pain due to muscle spasm.

A sacroiliac lesion is distributed over the gluteal region, posterior thigh, posterolateral calf and lateral border of the foot (Fig 238). This distribution of pain is commonly referred to as 'sciatica' and is present in the

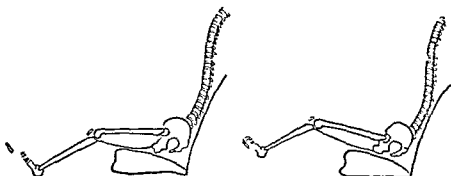


Fig 234.—Diagram showing strain from motor driving

*Local pain* is caused by localized swelling at the point of the lesion. *Referred pain* is pain referred along the peripheral distribution of the spinal nerve supplying innervation to the injured parts. The vertebral structures that is the ligaments, the periosteum and the synovia of the articular facets derive their innervation from the 'recurrent nerve' which is given off from each spinal

majority of cases of lesions of the sacroiliac joint (Fig 239).

*Radiation pain* results from tension of or pressure upon a nerve. A ruptured protruding intervertebral disk is a good example of

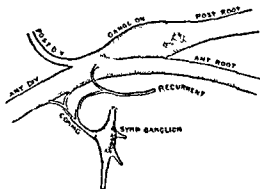


Fig 235.—Diagram showing the origin of the recurrent nerve (Quain's Anatomy)

nerve before the posterior primary division (Fig 235). Consequently lesions of the lumbar spine may be accompanied by pain referred to the anterior aspect of the thigh and leg (Fig 236). It is helpful to note that the five lumbar nerves supply innervation to the entire anterior aspect of the thigh and leg.

The sacroiliac ligaments derive their innervation from the first and second sacral nerves (Fig 237) hence referred pain from

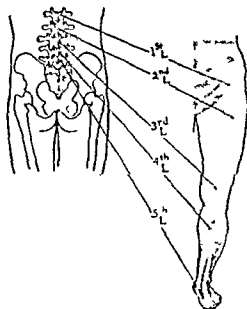


Fig 236.—Diagram showing the distribution of the lumbar nerves to the anterior aspect of the lower extremity

a condition accompanied by this type of pain.

*Pain resulting from muscle spasm* is never mentioned as a separate entity; it is usually included in the description of the primary pain resulting directly from the lesion. In response to a painful lesion protective mus-



cle spasm occurs as long as the local pain and sensitiveness persist muscle spasm per



Fig 232—Diagram showing the innervation of the sacral elements (Rudinger)

sists. Muscles continually contracting exert a continuous tension or pull on their peri-

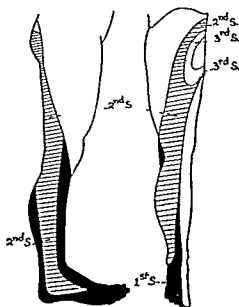


Fig 233—Diagram showing the distribution of the first and second sacral nerves (Tinev and Riley)

osteal attachment giving rise to pain which the writer likes to refer to as "secondary

pain." In lumbar lesions there is this muscle spasm of the erector spinae and to some extent also of the glutei. In sacroiliac lesions also there is spasm of the same muscle groups so that secondary pain produced by such protective muscle spasm is the same in the two regions (Fig 231). This is one reason for the confusion that exists in the differential diagnosis between the two regions.

A careful history is of the utmost importance in localizing a lesion as well as in determining the structures involved, particularly a lesion involving the lower back.

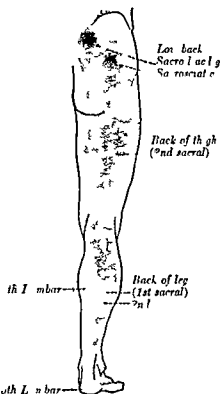


Fig 234—Diagram showing the subjective distribution of pain in sacral lesions ("scatica")

Lesions of this region always necessitate a differential diagnosis between those of the lumbar and lumbosacral regions and those of the sacroiliac joints. An accurate description of the onset of symptoms usually yields valuable information. If the lesion is due to some disease the history of any illness preceding the onset is important; if it is due to trauma then a detailed description of the injury must be obtained. An accurate description of the distribution of pain is particularly helpful in localizing a lesion.

**Examination.**—*Inspection* does not as a rule yield much information that is helpful

in making a differential diagnosis between lumbosacral and sacroiliac lesions. The patient's posture (Fig 240) should always be noted, since faulty posture predisposes to strain of both regions. The same is true of structural scoliosis—a mechanically unstable

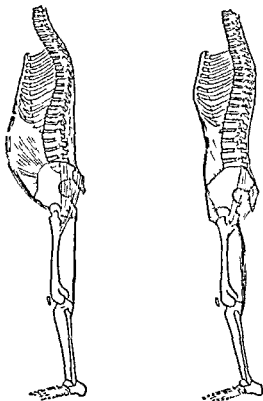


Fig 240.—Showing faulty posture and correct posture

spine. The presence of muscle spasm and of lateral or anteroposterior deviation of the spine gives some information as to the acuteness of the condition but again does not differentiate between the two regions, since a temporary deformity of this type may be present in either. The presence of a kyphosis as a rule means disease or fracture with resulting deformity of one or more vertebral bodies. A prominence resembling a kyphosis is frequently seen at the dor-lumbar junction because of faulty posture; roentgenograms are sometimes required in order to rule out disease.

**Palpation.**—If a patient complains of a tender spot anywhere, one's first reaction is always to put a finger on it. This is an illogical method of approach because poking a sore spot makes it sorer, creates more muscle spasm and increases the difficulties of palpation. It is distinctly better to palpate

first those regions which are the least apt to give rise to pain. With this in mind one should systematically conduct palpation and do it in such a way that at all times one knows what anatomical structures are being palpated. Localized tenderness anywhere as a rule means a lesion of that particular region. This is true of the spine as well as of any other part of the body. In fact, tenderness is even more significant in the case of the spine, because the structures involved are so deep seated that they rarely give rise to any visible surface changes.

Diagrammatic representations of points of information regarding the lumbar, lumbosacral and sacroiliac regions are given in figure 241. Starting at the dor-lumbar junction, tenderness over the costovertebral angle may indicate the presence of some genitourinary lesion as well as injury to the transverse process of the first lumbar vertebra (Fig 241, 1). From this region one pro-

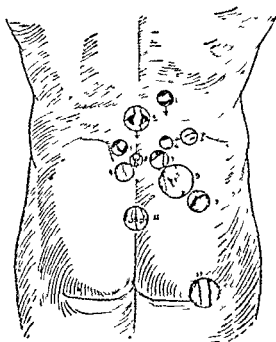


Fig 241.—Diagram showing points of palpation in the examination of lumbar, lumbosacral and sacroiliac disorders. (See text.)

ceeds downward, palpating the transverse processes of all the lumbar vertebrae as well as the overlying erector spinae muscles for tenderness. Tenderness at any one point may indicate fracture of the transverse process or a sprain of muscle attachments.

In palpating the spinous processes and interspinous ligaments (Fig 241 2) any deviation of the spinous processes in the anteroposterior or lateral plane must be particularly noted as such a deviation may indicate a fracture of the spinous processes or of the vertebral bodies or disease of these structures. Tenderness of the interspinous ligaments is indicative of acute sprain or strain due to faulty posture.

Tenderness in the region of the articular facets (Fig 241 3) between the fifth lumbar and first sacral vertebrae is consistent with a lumbosacral sprain from a hyperflexion or hyperextension injury or from strain due to faulty posture. It may also be due to a muscular sprain since the erectors spinæ overlie the facets.

Pain or tenderness referable to the dorsum of the sacrum (Fig 241 4) is most commonly accounted for and the basis of an exaggerated lordosis with a postural and muscular strain. It may also be present secondary to protective muscle spasm accompanying an acute sprain either lumbar or sacroiliac.

The region of the iliac crests (Fig 241 5) may be tender because of muscle sprain of the origin of the iliocostalis muscle. Most commonly this point is used as a landmark in locating the spinous process of the fourth lumbar vertebra.

The iliolumbar angles (Fig 241 6). The transverse process of the fifth lumbar vertebra, the iliolumbar ligaments and the erectors spinæ are the structures under the palpating finger. Tenderness at this point suggests possible fracture of the transverse process, strain of the iliolumbar ligaments due to faulty posture as well as an acute sprain of the same structure or of the erectors spinæ. A unilateral sacralized transverse process of the fifth lumbar vertebra sometimes gives rise to tenderness and pain referable to the iliolumbar angle.

The posterior iliac crest and posterior superior spine (Fig 241 7) are chiefly important as anatomical landmarks but sometimes this region is sensitive in cases of muscle sprain or strain.

Spinous processes of the fifth lumbar and first sacral vertebrae (Fig 241 8). Tenderness is present here in cases of faulty posture and frequently in spina bifida occulta with

an ununited spinous process of the first sacral vertebra.

The region between the posterior superior spine and the posterior inferior spine (Fig 241 9). Here are located the inferior sacroiliac ligaments which are practically invariably sensitive in any lesion of the sacroiliac joint but particularly so in sacroiliac strain or sprain.

The sacrosciatic notch (Fig 241 10). It is worthwhile to palpate this region since it commonly shows tenderness whenever the inferior sacroiliac region is tender. The reason for this is that at this point the superior gluteal nerve after passing in front of the sacroiliac joint emerges and passes to its peripheral distribution. Any condition causing swelling in relation to the anterior aspect of the sacroiliac joint will secondarily involve the superior gluteal nerve and cause tenderness of its nerve trunk. Consequently tenderness at the sacrosciatic notch may be interpreted as evidence suggestive of a sacroiliac condition.

The sacrococcygeal junction (Fig 241 11). Tenderness of these ligaments must be interpreted as evidence of a sacrococcygeal injury—sprain, strain or fracture.

The sciatic nerve trunk (Fig 241 12). Tenderness in this region midway between the greater trochanter and ischial tuberosity at the level of the gluteal fold is of no value so far as a differential diagnosis is concerned. It represents simply sensitiveness of the sciatic nerve trunk which may accompany either lumbar or sacroiliac conditions. The logic of this statement is evident when it is recalled that the sciatic nerve is made up of the fourth and fifth lumbar and first, second and third sacral nerves.

The foregoing outline gives an illustration of a systematic method of palpating the lumbar, lumbosacral and sacroiliac regions. Such palpation should be carried out with the patient in the different positions—standing, sitting and lying. Sometimes valuable information is obtained by palpation during the motions of flexion and extension.

*Motions*—In examining the mobility of a patient's spine there is one point that should be kept in mind. No information is gained by trying to find out *how much* the patient can be hurt. A great deal of information is gained by finding out *when* pain commences.

The patient therefore should be instructed to stop as soon as pain comes on if he is performing a motion actively; the examiner should stop if performing a passive test such as straight leg raising or passive lumbar flexion.

Motions if properly conducted should yield considerable evidence which will be helpful in the making of a differential diagnosis. This is true only if they are performed in the standing, sitting and lying positions. Forward bending standing (Fig. 242) when

structures under tension consequently the erector spinae remain taut preventing motion through the lumbar spine so that the motion takes place in the dorsal spine and in the hip joints, the pelvis pivoting forward.

Lateral bending is not particularly instructive as a differential sign but it may be confirmatory of other findings. If for instance a unilateral ligamentous or muscular sprain is suspected because of the type of injury and distribution of pain, then bending to the opposite side will put the injured structures

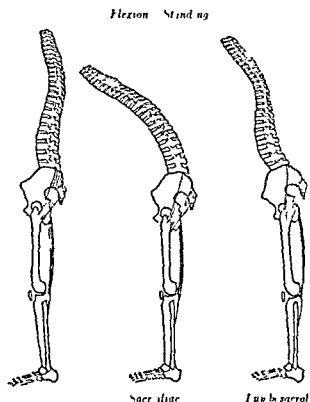


Fig. 242—Diagram showing the characteristic forward bending in sacro iliac and lumbosacral disorders.

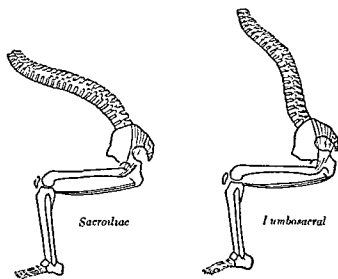
the spine is normal produces flattening and reversal of the lumbar curve, exaggerating the dorsal curve. How is this motion performed by a patient with a lesion of the sacro iliac or lumbosacral region? A patient with a sacro iliac condition bends forward in such a way as to avoid hamstring leverage transmitted through the pelvis and consequently flexes the lumbar spine to the limit of its elasticity but stops as soon as the pelvis tilts forward rendering the hamstrings taut. A patient with a lumbosacral condition if this condition involves the posterior ligaments, articular facets or erector spinae attempts to avoid putting the

on the stretch and consequently bring on or aggravate the pain.

Flexion while sitting (Fig. 243) normally can be performed so that the chest actually comes between the knees if these are kept separated. How is this motion performed in lumbosacral and sacro iliac conditions? A patient with a sacro iliac lesion frequently is able to bend freely, flexing the spine and tilting the pelvis forward; the reason for the free motion in the sitting position is of course the relaxation of the hamstrings caused by the flexed knees. A patient with a lumbosacral lesion bends forward in the same manner as he did standing since the lumbar struc-

tures, if sensitive, can move no more freely in the sitting than in the standing position; the curves of the spine therefore do not

as forward bending sitting, and in the case of a sacroiliac lesion, it can be performed as a rule quite freely, since the pelvis moves as



*Flexion - Sitting*

Fig 243—Diagram showing the characteristic forward bending in the sitting position in sacroiliac and lumbosacral disorders

change, and whatever motion takes place occurs at the hip joints.

Motions while reclining are exactly the same as when standing and sitting, with the

a whole and the hamstrings are relaxed. In lumbosacral conditions the examiner can easily flex the hips, but as soon as any leverage is transmitted to the lumbar spine which

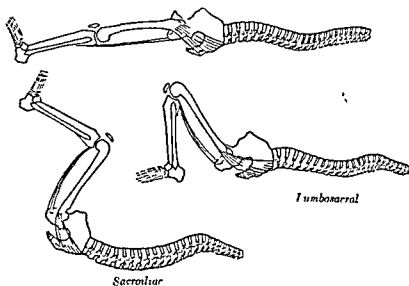


Fig 244—Diagram showing the characteristic passive lumbar flexion in sacroiliac and lumbosacral disorders.

difference that in the lying position they are performed passively by the examiner, whereas in the standing position the patient performs them actively. Passive lumbar flexion (Fig. 244) then is exactly the same

tends to diminish the lordosis, pain comes on and muscle spasm prevents any actual flexion from taking place.

The test of straight leg raising (Fig. 245) is a reversal of forward bending standing.

By this test the hamstrings are put under tension passively, tending to rotate the ilium backward thereby subjecting the sacroiliac ligaments to strain and producing pain. Consequently in sacroiliac conditions this test is markedly limited on the affected side; it may also be limited on the opposite side in acute cases. The pain produced is always referred to the side complained of, no matter on which side the test is performed. In cases of lumbosacral strain straight leg raising may be restricted but never to the same extent as in sacroiliac conditions, and the restriction is the same on both sides. In cases of rupture of the intervertebral disk this test produces an increase in the radiation

spine without aggravation of pain, since this motion tends to render the iliopsoas muscle tense thereby rotating the ilium forward and relieving the sacroiliac joints from strain. If disease is present this is of course not true, since the tightening of the psoas muscle lateral to the sacroiliac joints will tend to put the diseased area under pressure. In patients with lumbosacral conditions this test may or may not be productive of pain. If there is a ligamentous sprain the posterior ligaments of the spine will tend to become relaxed and therefore no aggravation of pain will result. The opposite is true of a muscle sprain; hyperextension puts the muscular attachments to the periosteum under

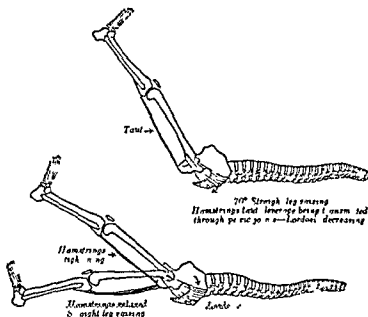


Fig. 215.—Diagram illustrating the test of straight leg raising.

pain owing to the tension of the spinal nerve at the level of the rupture. The peripheral structures innervated by this spinal nerve are hypersensitive, consequently, any motion or test which puts them under tension causes aggravation of pain. The straight leg raising is therefore limited to a lower angle with the horizontal plane (commonly 25 or 30 degrees) than in any other spinal or sacroiliac condition.

The motion of hyperextension is best performed in the lying position; if the condition is at all acute it is very difficult indeed for the patient to extend the spine in the standing position. A patient with a sacroiliac condition is able to extend and hyperextend the

spine and will therefore aggravate the pain. If the condition involves the articular facets there is aggravation of pain.

**Röntgenologic Diagnosis.**—By a careful examination the x rays are localized over the region suspected of injury or disease. Furthermore by taking films in different positions such as maximum flexion and maximum extension one obtains additional information in regard to mobility. Very frequently roentgenograms taken in this way demonstrate lesions that are not demonstrable in the routine anteroposterior and lateral planes. Lumbar puncture followed by the injection of a radio-opaque substance such as lipiodol is of great help in diagnosing an l

muscular sprain adhesive strapping (Fig 247) is sufficient it should be applied over the attachments of the muscles involved in such a way as to diminish their function. In

or brace is therefore indicated. A belt (Fig 248) if properly constructed gives efficient support for both the lumbosacral and the sacroiliac region. It gives pressure over the

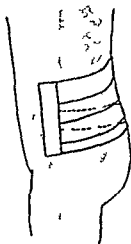
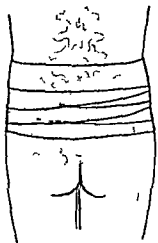


Fig 247.—Diagram illustrating the proper application of adhesive strapping to lumbosacral and sacroiliac regions.

ligamentous sprains of the lumbar spine adhesive strapping is efficient at first if it is applied in a position of extension preventing flexion. Since ligamentous sprains require

gluteal regions tending to tilt the pelvis into a more vertical plane and at the same time lifts the lower abdomen. In other words it assists muscle groups on which the normal position of the pelvis is dependent. It also

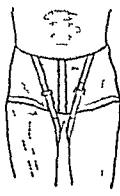


Fig 248.—Diagram illustrating the effect of a properly constructed belt for the treatment of lumbosacral and sacroiliac conditions.

protection for a period of from six to twelve weeks. Adhesive strapping is usually not adequate and the patient's skin will not as a rule stand it for this length of time. A belt

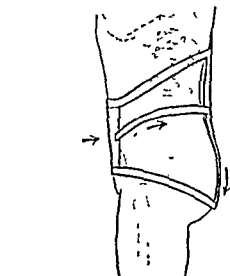


Fig 249.—Diagram illustrating the leverage of a lumbar back brace.

affords a compression of the soft parts against the lateral aspects of the ilia, thereby directly supporting the sacroiliac joints. A steel brace (Fig 249) is commonly used for the support of the lumbar spine and lumbosacral junction. It is effective in supporting

these regions but it does not efficiently protect the sacroiliac joints excepting in so far as it tends to render the pelvis more vertical.

Plaster casts should not be used in the treatment of sprains or strains. If properly applied they protect the joints involved but their effect is far reaching both physically and mentally. They produce muscle atrophy and joint stiffness their effect on the patient's mind is decidedly unfavorable since they make the patient feel the injury must be very serious indeed to require such treatment. This is particularly true in industrial accident cases.

During the period of ambulatory treatment supportive measures should be supplemented by exercises. These at first consist chiefly in assuming corrective positions followed later by exercises which tend to correct faulty position and increase the mobility of the spinal joints.

Manipulative treatment is indicated only if the physical examination yields evidence of a disaligned sacroiliac joint. The principle of such manipulation is hyperextension of the spine and hip; this principle has already been applied in the position in which the patient was kept during recumbency. If this is not sufficient then active manipulation by the surgeon may be undertaken with or without an anesthetic. If rupture of the intervertebral disk is suspected manipulative treatment is contraindicated since it may result in further protrusion of the ruptured portion of the disk and permanent harm to the cruda equina or spinal nerve. In such cases prolonged support in neutral position or in slight flexion is indicated. If conservative measures fail operative removal of the ruptured portion of the disk with or without fusion is indicated.

Throughout the acute stage drugs are in

articular facets or the spinous processes. When such underlying conditions are present operative treatment is advisable in order to achieve permanent relief. These operative measures consist in fusion of rations of one type or another of the lumbar and lumbosacral regions. By a fusion operation is meant either a massive tibial bone graft by the method of Allee or a Hibbs fusion operation or some modification of these two principal methods. The object of such operative treatment is to eliminate motion in joints which are mechanically imperfect.

In cases of chronic sacroiliac strain there need not be an anatomical variation. An acute sprain of this joint very frequently means a permanent weakening of the supporting structures so that even though the acute symptoms may be temporarily relieved a recurrence is brought about as soon as the patient attempts to resume his normal activities. By such recurring strain damage is done not only to the supporting structures but also to the hyaline cartilage covering the joint surfaces. Consequently the congruous surfaces no longer lock as they do normally. To overcome such instability of the sacroiliac joint fusion operations of various sorts are again indicated.

The underlying principle in fusion operations of the sacroiliac joint is anchorage of the ilium to the sacrum. This can be brought about either by extra articular or intra articular bone grafts. The extra articular fusions aim to produce bony bridging between the posterior iliac crest and the dorsum of the sacrum; an intra articular fusion operation produces bony bridging through the center of the joint.

M. N. SMITH, PETTIST



trophic arthritis degenerates arthritis non-ankylosans arthritis osteoarthritis osteoarthritis deformans arthritis deformans senilis arthritis alium coxae senilis indolens progressive osteoarthritis Type II (Fib) Type I (Chondro-osseous—Fisher) monarticular type nonpausal as applied to the spine osteoarthritis hereditary traumatic kyphosis von Reckterew type, arthritis deformans

**Definition**—Chronic arthritis is a widespread low grade chronic progressive inflammation of doubtful etiology involving the tissues and structures of one or more joints. The chronic involvements of joints arising from the invasion of specific organisms such as the tubercle bacillus, the gonococcus, the pneumococcus or similar organisms are not included under the term chronic arthritis.

Chronic arthritis is the oldest disease in both man and animal of which we have skeletal evidence. It is widespread throughout the animal kingdom and is present in practically all parts of the world. Probably no other disease produces such generalized disability and consequent economic loss.

By general acceptance chronic arthritis has been divided into two main subdivisions: (a) the atrophic type and (b) the hypertrophic type.

**Differentiation** between the two types of chronic arthritis. The atrophic type is an infectious involvement of one or more joints occurring in the earlier decades of life. It is marked by swelling of the soft parts surrounding the joint and causing it to assume the configuration of a spindle; this is associated with pain and limitation of motion. The limitation of joint motion is due first to muscle spasm but later to the adhesions developed within the joint. Fluid is usually present within the joint space. Ankylosis of the affected joint is the common outcome of the infectious inflammation. Histologically the atrophic type is marked by an invasion into the synovial membrane and villi of small round cells and occasionally of neutrophils together with the growth of a pannus over the articular surface of the cartilage.

The hypertrophic type is a joint inflammation of unknown etiology; it is more common in the later decades of life and more frequent in females. With the exception of the middle and terminal finger joints, the larger joints of the body are more often involved than the smaller ones. The affected

joint becomes distorted and mechanically damaged but does not become ankylosed excepting in the spine. Rarely is there marked limitation of motion; painful swelling or fluid within the joint cavity. The chief histologic change is that of irregular overgrowth of new bone especially at the margin of the capsule insertion. The changes are a combination of osseous degeneration with those of a low grade inflammation.

**Etiology**—In the atrophic type of chronic arthritis it is generally regarded that the disease is due to infection. Despite a great amount of detailed study, the isolation of a specific organism proved to be impossible for the condition has failed. Many investigators have isolated from the blood stream joint cavities or other sites various streptococcal strains which they regard as causative. In no case have these strains been substantiated. The specific organism or virus responsible for atrophic arthritis remains to be isolated.

The basis on which the belief in the infectious origin of this type of arthritis is founded lies in the clinical course of the disease, the concomitant occurrence of foci of infection in other parts of the body and on the pathology of the joint involvement. When considered these factors permit of no other interpretation.

The rapidity with which the atrophic type developed in young Marines subjected to jungle combat was most startling. Four to six weeks was sufficient time to permit extensive joint involvement especially of the spine. It was my impression that extreme fatigue was the most important predisposing factor.

The causative agent of the hypertrophic type of chronic arthritis is unknown. An infectious origin is unlikely. Because there frequently occurs in patients suffering with this disease a faulty digestion of food products and distinct abnormalities of intestinal function it is believed that the absorbed products of incomplete digestion may be largely responsible. The frequency with which diminished local circulation is found to occur in this type leads to the belief that such a phenomenon may play an important causative role. Experimental evidence adds weight to the significance of faulty circulation as a factor. Insufficient stress has been

laid on the role of local joint trauma as a predisposing factor. Such trauma need not be excessive but may comprise merely the stresses and strains of normal life on inferior joint structures. Experimental work has shown that (1) articular cartilage cells diminish numerically with advancing age, (2) the nuclear volume does not lessen with aging, (3) old cartilage cells split glucose as readily as young ones and (4) the ability of old cells to consume oxygen is far less than that of young cells. (5) It is suggested that the degenerative changes of articular cartilage which accompany aging are related to (a) a diminution in the number of the cartilage cells incident to age and (b) the inability of the old cartilage cell to breathe adequately. The factors of mature age and increased body weight of the persons who suffer from this type of arthritis give added significance to the importance of trauma as a deciding factor.

**Pathology of Chronic Arthritis—Atrophic Type—HISTOLOGIC CHANGES IN THE SYNOVIAL MEMBRANE**—There is a well defined numerical increase and hypertrophy of the synovial villi. All are in a state of inflammation. In some the synovial fringes are necrotic in other hemorrhagic. About the blood vessels of the synovial membrane and villi are found numerous massed aggregations of small round cells. The villi during the early stages are highly vascular but later their fringes become fibrotic or necrotic as the lumen of their vessels becomes obliterated.

**CAPSULAR CHANGES**—Fibrous bands are formed early by the organization of the inflammatory exudate in the capsule and synovial membrane. These shorten and produce contractures of the part. Calcification of the bands ensues and the joint becomes fixed.

**ARTICULAR CARTILAGE CHANGES**—These occur early in the disease but are usually subsequent to the changes in the synovial membrane. A most important and characteristic feature is the development and gradual inward growth of a pannus on the joint surface of the articular cartilage. Composed of a highly vascular tissue the pannus resembles granulation tissue. The deeper layers of the pannus invade the articular cartilage alter its structure and destroy its integrity. In this manner the original surface

of the articular cartilage is gradually replaced by a layer of connective tissue which not infrequently contains nodular areas of newly formed cartilage.

**EPIPHYSAL BONE CHANGES**—In the cancellous spaces of the epiphysis and in the subarticular bony lamella there occurs connective tissue proliferation associated with the formation of new blood vessels and accompanied in many cases by invasion of lymphoid and plasma cells. There is an increase of osteoblasts; these attack the bony trabeculae and by resorptive activity enlarge the cancellous spaces. New bone is soon laid down. Processes of vascular connective tissue preceded by osteoblasts penetrate the zone of provisional calcification. New subarticular bone is formed. From its under surface the articular cartilage is attacked and destroyed in circumscribed areas by invading connective tissue. The cartilage cells of the articular cartilage are destroyed and replaced by connective tissue. New cartilage and bone. This upward invasion meets with the downward growth of the pannus which has formed on the articular surface of the cartilage. The process is neither regular nor uniform. The articular cartilage is destroyed in patches through degeneration and as it is replaced by fibrotic elements there is produced an uneven irregular bony articular surface. Even in the earlier stages owing to the absorption of calcium salts an atrophy of the bone is seen roentgenographically.

**Hypertrophic Type—SYNOVIAL MEMBRANE CHANGES**—These usually are not apparent until lipping of the articular margin has occurred. At the point of lipping the synovial membrane is thickened and there is proliferation and enlargement of pre-existing villi and formation of new villous processes. The synovial fringes retain vascularity late into the disease. The involvement of the synovial structure is not as extensive as in the atrophic type.

**CAPSULE AND INTRA ARTICULAR STRUCTURE CHANGES**—In a remarkable manner the joint capsule migrates to accommodate itself to the altered contours of the bones in those cases in which erosion and shortening of the articular bone ends occur. The intra articular menisci or semilunar cartilages degenerate and disappear.

**ARTICULAR CARTILAGE CHANGES**—The first changes are seen in the central poorly nourished portion of the articular cartilage. The semitranslucent white cartilage becomes yellow and opaque. It becomes pitted and fibrillated, frequently the matrix splits longitudinally. Erosion and pitting continue and at the bottom of the pits denuded bone may be seen.

Epiarticular ecchondroses appear as rounded elevations with a smooth surface and give an irregular granular appearance to the cartilage. They are caused by the invasion of the deeper layers of the articular cartilage by vascular ingrowths of osteoblasts engaged in forming new bone or to ossification occurring in the center of the articular cartilage which has previously undergone local hyperplasia. As the condition continues the cartilage disappears revealing bone.

**LATERAL PORTION OF ARTICULAR CARTILAGE**—The more viable and vascular lateral portion hypertrophies and projecting laterally produces lipping at the articular margins. This formation of new cartilage at the margin succeeds the degenerative changes of the central portion. The chondrophytes so formed ossify through the invasion of osteoblasts from the neighboring bone and become osteophytes.

**PERIPHERAL BONE CHANGES**—Before the articular cartilage has disappeared the underlying bone is found to be thickened and denser than normal. Occasionally the periosteum near the articular margin proliferates and forms osteophytes (Heberden's nodes). Beneath the dense bone the cancellous spaces are unusually open and fat filled. Cysts may be found in inclusion masses of cartilage beneath the sclerotic zone. The exposed bone surfaces undergo churning and become polished. Owing to the atrophic processes going on in the bone immediately beneath the articular surface considerable alteration in shape of the articular surface takes place as a result of pressure. Absorption is most marked where pressure is greatest. Actual shortening of the bone may take place.

**Symptomatology - Atrophic Type**—Since it usually attacks the thin pliant undernourished young adult the atrophic type of chronic arthritis involves most frequently

the smaller joints. The early symptoms are those of local stiffness, pain, tenderness, swelling and temperature change. These vary greatly in degree. Stiffness may be evidenced merely by the feeling of lack of freedom of joint motion or by the actual limitation of motion by muscle spasm. Limitation of chest expansion is one of the earliest signs of involvement of the spine. Pain may be absent when the joint is at rest or constant and of excruciating severity. Tenderness may be elicited with difficulty or produced by the weight of the bed clothing. Swelling may not be visible but can be detected by palpation. The joint outline becomes fusiform frequently there is marked distention of the capsule by fluid within the joint cavity. Heat of the part is present in some degree. Later symptoms are but progression and regressions of the earlier symptoms. Pain is usually less severe. Muscle weakness with local and peripherally spreading atrophy is most common and characteristic and is frequently of such severity as to be completely disabling. The limitation of motion is progressive. Deformities: Flexion contracture of the part usually occurs and frequently despite intelligent attempts at prevention. The resulting deformation is pitiful in the extreme. Cutaneous manifestation: Vasoconstriction and inflammatory thickening of the peripheral phalangeal arterioles and capillaries cause the nails to become discolored and brittle. Numerous dermatoses occur secondary to the disease and are resistant to treatment.

**Hypertrophic Type**—**Early Symptoms**—Stiffness is far less marked than in the atrophic form. Muscle spasm is frequently absent. The range of joint motion is usually slightly decreased. Pain is absent when the joint is at rest and is usually not elicited when the joint is moved through its free range. Motion beyond the range of limitation may produce pain as may weight bearing. Palpation of the lateral margin of the joint elicits local areas of tenderness; this is particularly true of Heberden's nodes. Synovial involvement is manifested early by the ease with which backache is brought on by bending and the lifting of light weights. Pain referred along the intercostal or lumbar roots (intercostal neuralgia) is an early manifestation of spinal involvement. Swell-

ing of the larger joints is usually absent, but swelling of the smaller joints, especially during the development of Heberden's nodes on the finger is common. *Temperature changes* are usually absent excepting in the area of the finger joints. **LATE SYMPTOMS** *Pain* is only present after overactivity, it is more pronounced in the hip joint and over the exostoses than elsewhere. *Muscle weakness and atrophy* are absent. *Limitation of motion* is progressive because of the distortion of the joints by bony overgrowth. Neither fibrous nor bony ankylosis occurs except in the spine. *Deformities* are present in the nature of local distortion of the joint contour, but flexion contractures are not common excepting in the fingers. Here they are due to bony overgrowth rather than to fibrotic contracture, as in the atrophic type.

**Diagnosis**—The diagnosis is based on the symptomatology and physical findings.

**Atrophic Type**—**ROENTGENOLOGIC EXAMINATIONS** in the earlier stages are frequently considered negative by the inexperienced, but careful examination will show a degree of decalcification with lace-like trabeculation. The periarthritic structures are found to be more dense and swollen than normal and an increase of the joint cleft can usually be demonstrated. As the disease advances, atrophy increases and evidence of ankylosis is seen together with changes in the contour of the epiphyses.

**LABORATORY FINDINGS**—The basal metabolic rate is lower than normal. Mild secondary anemia is present and is frequently associated with mild leukocytosis. The blood pressure is low. The body temperature is subnormal or slightly elevated. During the active stage of the disease the erythrocyte sedimentation rate is above normal. Cecil and others have found that the blood serum agglutinates in a high titer various strains of hemolytic streptococci.

**Hypertrophic Type**—**ROENTGENOLOGIC EXAMINATION** early shows the presence of marginal "lipping" exostosis and irregular bone hypertrophy. There is absence of decalcification. The bone overgrowth and consequent distortion of the joint frequently become most excessive.

**LABORATORY FINDINGS**—The various routine and special examinations fail to give any characteristic findings.

**Prognosis**.—As far as the occurrence of disability, deformity and invalidism is concerned the prognosis in the atrophic type is extremely poor and will remain so until a truly specific therapy is evolved. The present state of therapy does not warrant an optimistic outlook. Much can be accomplished as regards prevention, amelioration and control of the more severe deformities, but the disease, when viewed in its entirety, is a depressing one.

The hypertrophic type presents a less somber prognosis. It is more amenable to treatment and chiefly because of the grossness of its pathology, lends itself more suitably to the surgical and mechanical correction of distortions.

**Treatment**—The only hope for success in the treatment of chronic arthritis lies in thoroughness and persistence. There is no specific therapy. All branches of medicine must be employed, surgical treatment must be resorted to and above all the morale of the patient must be supported.

A most exact and detailed history should first be obtained, from such a history will be elicited many valuable suggestions as to treatment. By means of a physical examination one should strive first to estimate the bodily efficiency of the patient and to detect the presence of possible foci of infection. An orthopedic examination is made to determine the type of body build, posture, muscle tone, abnormal lines of weight bearing and the exact condition of the various joints. Nothing should be taken for granted, nothing overlooked. The smallest abnormality of structure or function should be detected and correction attempted.

The role of foci of infection in chronic arthritis has become insecure. To them can no longer be assigned the full responsibility for the disease and their removal is not always indicated nor attended by relief. Should the existence of foci of infection be proved and should the general condition of the patient warrant assuming the risk attendant on removal, then eradication is indicated. Most commonly, pyorrhea, an apical dental abscess, infected sinuses or tonsils or an infected gallbladder or appendix constitutes the focus of infection. The presence of cystitis, pyelitis, cervicitis, prostatitis or vesiculitis must not be overlooked. The large

intestine is frequently a veritable cesspool of pathogenic organisms. Though foci of infection may be located early, it is not always wise to remove them immediately, safer progress is made if the general health of the patient is first improved.

The patient suffering from chronic arthritis of either type is usually below par physically and is fatigued both mentally and physically. Relief of fatigue is the first step, the patient is put to bed for several weeks. The bed should either be boarded or should have a hard mattress. For several half hour periods daily the patient should lie on his back with a small pillow beneath the mid thoracic portion of the spine. Such a procedure aids in overcoming the existent hyperextension of the spine, increases the costal angle permitting greater ease in breathing and a consequently improved general circulation through more efficient heart action. The continued rest in bed relieves muscle spasm and permits relaxation of abnormal spinal and sacral joint alignment.

Pain should be controlled from the beginning by the adequate use of salicylates, but the relief of pain must not be considered as indicative of cure.

Diet is of the utmost importance. Patients with the atrophic type of arthritis are usually undernourished; those with the hypertrophic form are usually overweight. The diet of each form should be designed to correct the salient abnormality. In either case an adequate supply of vitamins B and D should be given together with a fair amount of bulky food of relatively low caloric value.

Physical therapy is of the greatest value in the treatment of chronic arthritis. The measures most used are local and general massage, colonic lavage, radiant heat and diathermy, immersion baths, passive and active motion and exercises.

The distended, sluggish colon of the arthritic patient cannot but be benefited by colonic massage augmented by occasional colonic lavages.

Very gentle massage of the structures about the affected joints should be given preceded by radiant heat. Massage and heat properly used will improve the deficient local circulation of a part and thus reduce materially the local swelling and edema. Vigorous local massage is contraindicated.

General massage following ultraviolet irradiation or exposure of the body to infra red rays should be used to improve the muscle tone and the general circulation. Passive motion of an affected part should not be permitted until the local resistance has been improved through the judicious use of massage. When started motion should be slow and never carried to the limits of the motion range of the joint. When the patient has been taught his limitations, active motion of the part may be permitted, but never to the point of fatigue. Exercises are prescribed to bring into use all the muscles of the body. great care must be given to the choice of the exercises and to the manner in which they are performed. Fatigue must be avoided.

Immersion baths of heated hypertonic salt solution are beneficial. Local contrast temperature sprays stimulate the local capillary circulation by producing local vasodilatation which persists for some time.

During the past ten years the author has had gratifying results from the intravenous treatment of the less severe forms of hypertrophic arthritis with colloidal sulfur. The clinical results contradict the adverse experimental data on the properties of this substance.

**Vaccines**—The arbitrary use of vaccines is to be discontinued.

**Chemotherapy**—The sulfonamides have a limited value in the treatment of the atrophic type. Penicillin has given remarkable results in a very small series of cases of the atrophic type. Its further use is indicated on an empiric basis.

**Operative Treatment**—Operative treatment includes both mechanical and operative measures. The former consists of the application of supportive bandages, braces and corsets as well as the insertion of pads, wedges and lifts in the shoes. These measures are designed to correct faulty posture, to limit the joint motion or to support weakened muscles and relaxed ligaments.

Operative measures may be used to correct existing deformities. Such procedures comprise lengthening of contracted tendons and joint capsules to overcome flexion contractures, removal in whole or part of the synovial membrane of a joint (synovectomy), severance of ankylosed joints and plastic repair of the same (arthroplasty).

fusion of joints in positions of election (arthrodesis) and such other reparative or reconstructive procedures as the individual case may demand. Much benefit has been obtained by the author in mobilizing knee joints by excision of the patella and synovium. The wider use of operative measures would lessen materially the number of arthritic derelicts.

GEORGE WAGONER

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### SOME DISEASES OF BONE THAT ARE NOT INFECTIOUS IN ORIGIN

#### INFANTILE SCURVY

Scurvy is a generalized condition which is due to an insufficient amount of vitamin C in the diet. Most of the cases occur in the second half of the first year of life, although occasional cases are seen in older infants and in young children. It is characterized by changes in the gums which become swollen and purplish. In severe cases bullae filled with serosanguineous fluid may develop on the gums and if erupted teeth are present these may become loosened. In addition to the changes in the gums, the long bones especially the femora and humeri may be the site of subperiosteal hemorrhages. As the disease subsides under appropriate treatment the gums tend to return to normal but the subperiosteal hematomas may become calcified.

**Symptoms.**—The onset of the disease is gradual. The infant is pale, does not gain weight, is irritable, tends to cry when lifted or moved or when the extremities are palpated as though these extremities were tender and tends to lie with the lower limbs extended and externally rotated as though they were paralyzed. In such an infant more than six months of age and less than two years of age one should suspect scurvy and inquire concerning his diet. Areas of swelling and purplish coloration on the gums confirm the diagnosis.

**Treatment.**—The treatment consists of supplying an adequate amount of vitamin C. This is best obtained from oranges, lemons or tomato juice which should be given in doses of 3 teaspoonfuls three times a day or the concentrated vitamin C may be used. While frank adult scurvy is almost unknown there is evidence that subclinical scurvy may occur in adults as a result of avitaminosis. For this reason surgeons who treat patients with chronic disease should consider their diet and see that it includes an adequate amount of ordinary foods and vitamins.

#### RICKETS

Rickets is a condition of early childhood which is characterized by weakness of the muscles and softening of the bones. It is due to faulty calcium metabolism which is manifested by failure in the absorption of calcium from the digestive tract. Since the absorption of an adequate amount of calcium depends on the ingestion of calcium and phosphorus in the food and also on an adequate supply of vitamin D, rickets may be produced experimentally by eliminating any of these substances. In the temperate zones rickets is one of the most common diseases of childhood. It is said that about 90 per cent of the children of the poorer classes in large cities are at some time affected with rickets. This does not mean that 90 per cent of the children have rickets to such a degree that their bones are deformed, but that a careful laboratory, clinical and roentgenologic examination of these children would reveal abnormalities which would come under the classification of rickets.

**Pathology.**—Pathologically the disease is characterized by the production of osteoid tissue which fails to calcify. Bone resorption proceeds normally or perhaps more rapidly than normal and new organic bone is produced but this is not impregnated with calcium salts and the resultant osteoid tissue may be bent or deformed from gravity or muscle pull. As the rickets heals the osteoid bone is calcified in its abnormal shape and this may result in a permanent deformity. In the roentgenogram the earliest change in rickets is seen as an irregularity and increased radiability of the epiphyseal line. As the disease advances the epiphyseal portion

of the bone broadens so that the epiphysis appears to be frayed out at its epiphyseal end and the zone of rarefaction becomes wider. As the disease heals calcium is deposited in this broadened rarefied epiphyseal region and is visible in roentgenograms.

**Symptoms.**—Rickets is insidious in its onset. The child tends to be lethargic, indolent and inactive. There is frequently no appearance of malnutrition and the child may be quite fat. He tends to sit with his back bowed forward and part of the body weight supported by the arms. The forehead is prominent and the fontanelles are slow in closing. As the disease advances the wrists, knees and ankles become enlarged and the rachitic rosy which is due to thickening of the ribs at the costochondral junction may be evident. With further progress of the disease the spine may be curved forward in a long gradual kyphosis, the abdomen tends to become protuberant, the chest tends to become flat at the sides (Harrison's groove) and deformities develop in the long bones. These deformities are partly due to gravity and partly due to muscle pull. The most common is an outward bowing of the entire lower extremity so that the deformity of genu varum—bow legs—is produced. The next most common deformity is anterior bow legs in which the tibia is bowed forward. Rachitic knock knees are also fairly common. Rather rare deformities are coxa vara in which the neck of the femur is bent downward and deformities of the arm and forearm.

**Treatment.**—For the purpose of treatment clinical rickets may be divided into medical and surgical rickets. Medical rickets including those cases in which permanent deformities requiring surgical treatment have not developed but in which there is an indication for the regulation of the diet with the administration of adequate amounts of calcium usually in milk and adequate amounts of vitamin D usually in sunlight, cod liver oil, haliver oil or viosterol. There are many children with mild deformities especially mild bow legs or knock knee. In the great majority of these cases the mild deformities will yield to conservative treatment (properly fitting shoes, manipulation and postural exercises or braces). Severe deformities which persist some year after the

rickets has healed should be corrected by osteoclasis or osteotomies. In osteoclasis the bone is broken by means of an osteoclast. This is advantageous because the operation is bloodless, requires a relatively short anesthetic and in addition to the breaking of the bone the soft tissues are stretched so that the deformity may be more easily corrected and held corrected in plaster. Osteotomy has the advantage that the correction can be made more exact (usually a wedge can be removed at the apex of the curve) but it has the disadvantage that there is always some danger of infection and that even after the bone is cut through there may be some difficulty in the correction of the deformity because of contracture of the soft tissues.

In addition to the deformities in the long bones children who have had rickets are apt to have flat feet. These may be amenable to correction by means of exercises and properly fitting shoes. On the other hand in older children there may be considerable deformity in the bones of the foot so that in spite of exercises and proper shoes the patient will remain flat footed unless an operation is performed for the correction of the deformity. This can be done and a foot with a good arch can be secured. Pathologic fractures may occur in florid rickets and should be treated adequately and the diet corrected.

### OSTEOMALACIA

Osteomalacia is a condition which occurs in adult life. It is due to a deficiency of calcium and of vitamin D in the diet. It is principally seen in women of the Far East, who subsist on a low calcium diet, who stay indoors most of the time and in whom pregnancy causes a marked drain on the calcium in the body. Other cases known as human osteomalacia were seen in large numbers in the central European countries during and after the first World War when the inhabitants of these countries subsisted on a diet low in calcium. The condition may be suspected in patients who complain of vague rheumatic like pains in the back and in the extremities. Rarely does the disease proceed to a point where pathologic fractures or deformities from bending bones are evident. In such a patient roentgenograms of the long bones show marked rarefaction al-

though of course none of the changes of rickets since the epiphyseal lines have disappeared

The treatment consists of supplying a high calcium diet plus an ample amount of vitamin D given as cod liver oil or viosterol. In senile osteomalacia treatment with follicular hormone is added to the high calcium and vitamin D regime for women.

### PAGET'S DISEASE

#### (*Osteitis Deformans*)

Paget's disease is a generalized disease of adult bone which is characterized by enlargement and softening. The etiology is unknown and though hyperactivity of the parathyroid has recently been suggested observations on calcium metabolism have not supported this theory. The pathologic changes consist of the transformation of the blood forming elements of the bone marrow into vascular connective tissue, the irregular resorption of the bone and the production of new bone which is largely subperiosteal. It is characteristic of the disease that the production of new bone, bone resorption and replacement by vascular granulation tissue go on side by side.

**Symptoms.**—Paget's disease occurs in middle adult life and is rarely seen before the age of thirty. The onset is insidious; the condition may progress very slowly and may be present over a period of years before any clinical symptoms arise. The bones most commonly affected are the tibia, skull, femur, pelvis and spine. As the disease progresses the affected bones become thickened and softened. With the softening of the bones deformities occur so that the tibia tends to be bowed forward and the femur outward while the spine develops a kyphosis; thus the patient loses in height and at the same time the head enlarges so that he must wear a larger hat. In some cases patients complain of rheumatic pains in the back, hips and lower extremities. They also complain of weakness and inability to lift or carry weights. In certain instances the pain may be so severe that a sedative is indicated for relief.

On physical examination enlargement and bowing of the bones may be noted. The af-

fected bones may be tender and there is a definite increase in the local temperature.

**Diagnosis.**—The diagnosis is confirmed by roentgenograms and many cases which cannot be diagnosed clinically are first suspected after the x-ray examination. Roentgenologically the affected bones have lost their normal structure and present irregular areas of increased density and of rarefaction. There is a definite tendency for some bones to be coarsely striated as though certain elements have been destroyed while other have become more dense than normal. On the surface of the bone there is evidence of the formation of new bone which has a cotton wool or fuzzy appearance and which produces an increase in the diameter of the bone. This is particularly true of the skull which may be markedly thickened. Since the bones are much weakened by the absorption fractures may occur from relatively slight violence and there is a tendency for them to be incomplete.

**Treatment.**—No known treatment has any effect on the progress of the condition. If fractures occur they should be properly treated and union may be expected to occur although it may be somewhat delayed. In three instances in which the patient suffered severe pain in one tibia the writer has removed a large area of the cortex over a distance of about 10 inches. This seemed to relieve the tension in the bone and relieved the pain at least over a period of a few years but did not have any effect on the general disease. A diet containing excess calcium and excess vitamins A, B, C and D is given to promote hardening of the bone. In about 10 per cent of these patients osteogenic sarcoma develops.

### OSTEOGENESIS IMPERFECTA

#### (*Brittle Bones and Blue Sclera Hypoplasia of the Mesenchyme Osteopathy*)

In a case of osteogenesis imperfecta the bones are abnormally brittle and the affected person suffers fractures from relatively slight violence. There are three types of this disease: 1. Congenital osteogenesis imperfecta in which multiple fractures occur in utero and in which large numbers of fractures may be present during the first few months of life. Infants with this type rarely



survive the first year. 2 Fractures are not present at birth and usually do not occur until the child begins to be active on his feet. Then the bones may be broken as a result of falls or slight accidents. 3 This type of case is similar to the second except that the condition is inherited from one or both parents and is transmitted as a dominant hereditary character to some of the offspring. The etiology is unknown except that there is an anomaly in the development of the skeletal system.

**Pathology**—Pathologically the bones are characterized by being unusually slender and may show relatively coarse striations in the roentgenogram. There is no disturbance of calcification and the calcium metabolism is normal. On microscopic examination the bones are found to be quite coarse in that the haversian canals are unusually large and may be irregular in arrangement. The epiphyses tend to be normal. The bones are not soft and do not bend but are broken by external violence.

**Symptoms**—In the congenital type of this disease with fractures present at birth or produced shortly after birth when the infant is lifted or moved the diagnosis is made on the basis of the presence of multiple fractures. In the second and third types the condition may not be suspected until a roentgenogram is taken and shows the abnormally slender bones. However the condition is frequently though not always accompanied by blueness of the sclera. In some patients the sclera is a clear china blue. In others there is little deviation from normal and in my experience the degree of abnormality in the sclera is not an indication of the degree of fragility of the bones. There is considerable variation in this fragility and some patients are able to lead a fairly active life while in others the bones are so fragile that the patients are practically bedridden even when braces are used and fractures are apt to occur when a relatively slight strain is put on their extremities.

The fractures are practically limited to the long bones especially the tibia and femur and a patient with a severe case may suffer thirty or forty fractures by the time adolescence is reached. The fractures tend to heal as do those of normal bone and the bone tends to be somewhat stronger at the

site of a healed fracture, but because of the repeated occurrence of fractures many of these patients are neglected and severe deformities develop which could have been prevented by the adequate treatment of each fracture when it occurred.

**Treatment**—If the patient can be maintained through childhood there is a definite tendency in a great majority of cases for the fractures to become less frequent as adolescence is reached. This is partly due to the fact that the patient has learned to avoid injury and partly due to the fact that the bones become somewhat stronger but they never reach a point where they can be compared in strength with those of a normal person.

Since the disease appears to be due to a deficiency in the laying down of the organic matrix of the skeleton and is not dependent on any abnormality in calcification no treatment has yet been found which influences the general condition. It is important however in these cases that the fractures be adequately treated when they occur otherwise deformities will develop. In cases in which deformities have developed these can be corrected by multiple osteotomies or osteoclasis and union may be expected after such operations. Affected persons should be warned that if they have children they may be expected to inherit the condition.

#### ACHONDROPLASIA

This is a type of dwarfism which is due to the abnormal development of the epiphyses of the long bones or to early ossification of these epiphyses. The condition is congenital though not a hereditary bone dystrophy.

**Diagnosis**—The diagnosis may not be made until the second or third year of life when it may be noted that while the child's body grows normally the extremities appear unusually short though normal in thickness. In such a case rickets may be suspected but a roentgen ray examination will show that there is no lack of calcification of the epiphyses in fact the epiphyses tend to be more calcified than normal. As the child becomes older the discrepancy in the length of the extremities as compared with that of the trunk increases so that the patient has short thick arms and legs and a long relatively straight torso. The head is large and

the forehead high and prominent the bridge of the nose may be depressed. The patients are alert and normal mentally and tend to lead an active life.

**Treatment**—There is no treatment which is known to influence the course of the condition.

### DYSCHONDROPLASIA

#### *(Multiple Cartilaginous Exostoses)*

This is a condition in which there is an abnormality in the growth at the diaphyseal end of the long bones and it is theoretically due to a failure of the periosteal sheath of the shaft to enclose the region completely and prevent the excess growth of cartilage. As a result tumors composed of a bony base, which may be either sessile or pedunculated, spring from the shafts of the long bones at or near the epiphyseal lines and project outward into the soft tissues. In the beginning these tumors are cartilaginous and as the patient grows older they become more and more calcified in the adult they may be composed almost entirely of bone with a thin cortical layer of cartilage. The parts most commonly affected are the upper end of the tibia, the lower end of the femur, the upper end of the humerus and the lower end of the bones of the forearm. These are the regions where growth proceeds most rapidly.

A patient may have a single tumor or a dozen or more. In addition to the tumor x-ray examination frequently reveals a disorganization of the epiphyseal line adjacent to the tumor with radiated areas projecting from the epiphyseal line into the cancellous portion of the shaft of the bone. In addition to the long bones the vertebrae, scapulae and pelvis may be affected. The membranous bones are not affected. In a considerable percentage of patients the condition is hereditary.

### OSTEOCHONDRITIS DISSECANS

Osteochondritis dissecans is a term given by Koenig to a type of loose body which develops in joints which are in other respects normal. The loose body is composed of a portion of the articular cartilage with a layer of the underlying cancellous bone. Koenig believed that the condition was due to a dissecting inflammation but repeated observations on numerous patients have connected the condition with trauma; it is now believed that as a result of a direct injury to the articular surface some of the bone loses its blood supply and becomes necrotic and that this with the overlying cartilage becomes separated and may eventually become free in the joint.

When the loose body is free in the joint it manifests its presence by interfering with motion and the joint may lock from time to time the locking usually being only momentary in character but accompanied by pain. In other instances the patient has some vague pain and disability in the knee and the loose body or joint mouse is discovered roentgenographically before it has become completely detached.

**Treatment**—The loose body should be removed even though it is discovered before it becomes completely detached because its presence in the joint not only leads to interference with motion but tends to cause chronic irritation in the joint and to produce chronic arthritis. If it is not removed the cartilage may continue to grow the body may become larger and may become fractured giving rise to multiple joint mice. If the loose body is in the anterior portion of the knee it should be removed by a lateral patellar incision and unless the base from which it has become detached is thoroughly healed and covered by fibrous tissue the base should also be excised. Loose bodies in the posterior capsule of the knee may be removed by a posterior lateral incision. Although they are usually found in the knee joint loose bodies are occasionally seen in the hip, elbow, shoulder or ankle and when discovered should be removed by arthrotomy.

## OSTEOCHONDROSIS OF THE GROWTH CENTERS

In the various ossification centers in the child a disease may occur which commonly involves only one growth center but which may appear in several or almost all the centers in one individual. This disturbance was originally referred to as an epiphysitis since it was early described only in the true epiphyses. In recent years it has come to be recognized that any center of bone growth such as the cuboidal bones of the wrist, tarsals and vertebral bodies as well as the true epiphyses may show the same pathologic change. Since the etiology is as yet unknown and the material for pathologic study is meager, a correct and generally accepted terminology has not developed. It would seem reasonable in discussing this disease to consider whether the process involves a primary center of ossification such as the spine (before puberty) and cuboidal bones of the wrist or a secondary center viz. tibial tuberosity, capital epiphysis of the femur, patella or calcis metatarsals spine (at puberty) etc.

Some short bones and some flat bones are ossified entirely from the primary center of ossification. Nearly all the secondary centers appear after birth. Many of the secondary centers appear near the time of puberty for example in the spine, tibial tubercle, pelvis, girdle, ribs, clavicle and rarely the patella.

The types of osteochondrosis under discussion are classified as occurring in either the primary or secondary groups depending on whether the primary center of ossification or the secondary center is first involved. The time of appearance and ossification of these centers is represented in figure 250. Osteochondrosis develops in ossification centers during the period of growth from one or both centers. This classification places all the cuboidal bones of the wrist and feet except the calcaneus in the primary group. The growth centers in the spine develop rather late and have two periods of active growth: the first involves the primary center during the first decade, the second the secondary centers during the second decade. A primary type may continue until the appearance of the secondary centers or the two types may appear simultaneously in the same patient.

**Etiology**—The etiology of this disease has not as yet been clinically or experimentally proved. It would seem however that trauma either in a direct or indirect form plays a major part in many instances regardless of location. A traumatic factor is often present in cases involving the elbow, tibial tubercle, head of the femur and second metatarsal.

Indirect violence due to increased stress and strain resulting from muscle or tendon traction is another important element. The disease is most common at the points of increased stress for example the head of the femur, the heel and the scaphoid. The vertebrae are usually involved in the low dorsal and upper lumbar region where the vertebral bodies are subjected to increased indirect trauma.

Hanson considers heredity as a possible etiological factor in vertebral disease. Leriche and Policard offer an explanation on the basis of vasomotor changes. Since the condition has occurred in several members of the same family as well as all the growth centers in several known cases, there may be some underlying endocrine or metabolic factor.

**Pathology**—It would appear that the pathology of this disease may be divided into two phases viz. that of degeneration and that of regeneration. In osteochondrosis of the hip it would seem that there is at first an early necrosis in the metaphysis of the neck of the femur and that necrosis later follows in the head usually at a point directly overlying the first area of necrosis in the metaphysis; it extends correspondingly in the head. It is suggestive that the degeneration in the head is the result of necrosis in the neck and so far as can be determined there is at all centers where this disease may occur a phenomenon of aseptic necrosis.

When the period of degeneration is complete the phase of regeneration begins. Regeneration is usually apparent in the metaphysis before it shows in the head. The cycle of degeneration and regeneration usually requires a period of between two and three years.

There is in the early stage subchondral necrosis of bone and marrow and an irregularity of the epiphyseal line. A lack of ossification in the early stages is noted and may

sion of the knee causes pain in the region of the ligamentum patellae. Roentgenograms show irregularity in shape as well as fragmentation of the tibial epiphysis. This common condition is self-limited, regardless of treatment. Mild cases may be relieved by cross strappings of adhesive tape, or in the more severe cases a plaster of paris splint may be necessary for a few weeks.

**Kochler's Tarsal Scaphoiditis**—Osteochondrosis occasionally manifests itself in the tarsal scaphoid. Its appearance in this location was originally described in 1908 by Kochler, who at the same time discussed its appearance in the patella. In the scaphoid it is frequently referred to as Kochler's disease, which is a primary type. The usual symp-

secondary type of the disease. It usually occurs in active, well developed boys between the ages of three and twelve, although girls are not entirely exempt. The first symptom is a limp, and this may be accompanied by local pain and tenderness. A certain number of patients give a history of trauma.

When the patient with osteochondrosis of the hip is first seen, the diagnosis can usually be made. Upon palpation of the hip, the head of the femur appears to be larger than normal, and the capsule does not feel thickened, as is true in tuberculosis. Some wasting of the gluteal muscles on the affected side can be seen. Some general muscle spasm, as well as pain and tenderness, may be elicited. The Trendelenburg sign is present.



Fig 251.—Roentgenogram showing osteochondrosis of the right hip

tom is aching in the region of the mid bony arch. The diagnosis is generally made by means of roentgenograms, which usually show an irregularity of contour and fragmentation of the scaphoid. The symptoms are as a rule relieved by adhesive strappings of the long arch, elevation of the inner heel of the shoe or a long arch support to be worn for a few months.

**Perthes' Disease**—The head of the femur is perhaps most frequently the seat of osteochondrosis. It was described by Legg and Perthes independently in 1910, and has been referred to by a number of terms, viz., Legg's disease, Legg-Perthes' disease, Perthes' disease, Legg-Calvé-Perthes' disease, osteochondritis coxae juvenilis, osteochondritis deformans, coxa plana, pseudocoxalgia or osteochondral trophopathy of the hip. It is a

Roentgenograms taken at this stage are characteristic. There is usually some broadening of the neck, with spotted areas of rarefaction below the epiphyseal line. The contour of the head may be slightly flattened, with multiple areas of rarefaction in the head.

The changes which occur in the head of the femur following reduction of a congenitally dislocated hip would appear to be those of an aseptic necrosis but arising primarily in the head of the femur rather than originating in the neck, as is suggested in primary osteochondritis of the hip.

Motion about the hip is normal unless the epiphysis has migrated to the greater trochanter, in such a case abduction and rotation are limited. Very little shortening of the leg occurs. The disease is to be differenti-

from tuberculosis coxa vara and congenital and acquired irregularities of the head of the femur as well as epiphyseal separation fractures.

The treatment whenever possible requires the child to be put to bed with Buck's extension on the affected leg, this is continued until the phase of regeneration as indicated by the roentgenogram is well advanced. When the child gets out of bed a well fitting walking brace with perineal crutch should be applied together with an elevated shoe on the opposite side. Weight bearing free of the brace should not be allowed until regeneration is practically complete.



Fig. 252—Histomicrograph of specimen removed from the right hip (Fig. 251) showing focal absorption of the matrix well vascularized but without ossification.

**Apophytitis**—When the disease is present in the os calcis it is referred to as apophytitis. It is the only example of the secondary type of the disease in the cuboidal bones. It occurs most frequently in active boys between the ages of eight and fourteen years. The patient complains of pain about the heel in walking. Examination reveals pain and tenderness over the back of the heel. Full dorsiflexion is limited and any strain on the tendo achillis causes pain. Roentgenograms often show the growth center to be enlarged and irregular in outline areas of condensation and rarefaction occur. Relief

may be obtained by lifting the heel from  $\frac{1}{4}$  to  $\frac{1}{2}$  inch. A soft felt or rubber pad may be placed under the heel.

**Freiberg's Infraction**—Osteochondrosis of the head of the second metatarsal bone is often referred to as Freiberg's infraction. Koehler's metatarsophalangeal osteochondritis and a second Koehler's disease. This occurs most often in girls between the ages of ten and fifteen years. Local pain in walking referred to the part affected is the chief symptom. Localized tenderness, periarticular thickening and swelling are present. Dorsal flexion of the foot may be limited. Involvement of the second metatarsal bone is more common than of the four remaining bones because it is longer than the rest and bears the brunt of the body forces. Roentgenograms establish the diagnosis. The head of the second metatarsal bone is flattened and irregular. The cortical portion of the diaphysis usually shows thickening. Relief is ordinarily afforded by a leather transverse bar  $\frac{3}{4}$  inch thick placed on a low heeled shoe just back of the position of the head of the affected metatarsal bone.

**Vertebral osteochondrosis** has usually been referred to as Scheuermann's disease juvenile kyphosis, adolescent kyphoscoliosis, kyphosis osteochondropathica, vertebral osteochondritis, vertebral epiphysitis, kyphosis dorsalis adolescentium, kyphosis dorsalis juvenilis. Attention to vertebral involvement was first aroused by Koehler in 1915. At present this is recognized as a fairly common condition more prevalent in girls than in boys.

Involvement of the primary centers may appear within the early years of life and produce a greater degree of deformity than the type occurring in the secondary centers. The secondary type is more common. In any patient with a well defined round back at adolescence this condition must be considered.

In osteochondrosis of the secondary centers of the spine the most frequent age of onset has been found to be between ten and eleven years. The incidence peak is highest earlier in girls being reached at ten years; in boys it is at eleven to fourteen years. The condition appears most frequently in the tall thin child with an asthenic constitution.

The symptoms and roentgenograms vary according to the degree of advancement of the primary or secondary types. Deformity is often the only complaint in either type. By the time the symptoms or deformity become severe enough to cause the patient to seek medical aid the roentgenograms are characteristic. There is early mottling and an irregularity of contour of the vertebral bodies most affected which are usually in the low dorsal region. The bodies may become wedge shaped resulting in angulation of the spine at this point. In the final stages sclerosis takes place and the mottled appearance decreases. The early spinal deformities may be mistaken for Pott's disease or rickets. Some of these patients complain of local discomfort at the site of angulation. The secondary centers are represented by small triangular bodies at the anterior superior and the anterior inferior margins of the vertebral bodies. The appearance of the disease in the secondary centers cannot take place until shortly before puberty when these centers appear. The roentgenogram usually establishes the diagnosis.

The treatment should be directed toward (1) prevention of deformity (2) correction of deformity if it has already occurred (3) the relief of pain and (4) the improvement of the general bodily posture.

During the early period of the disease when pain is complained of absolute physiologic rest is indicated. The child should be placed on a Bradford frame with an angulation of from 20 to 35 degrees. The apex of the curve of the spine should rest at the maximum angulation of the frame. When all muscle spasm has subsided the patient may gradually be allowed up. Sleeping on the hyperextended frame should be continued until all possible correction of the deformity has been attained. Corrective exercises should be directed toward hyperextension of the spine in such a manner as to restore the normal physiologic curves. In a few cases in which the deformity has not been corrected the patient may require a back brace to prevent an increase of the deformity or to relieve pain.

*Traumatic malacia of the carpal semilunar bone of Kienbock* as well as the same type of process in the spine known as *Kummell's disease* occurs in adults usually as a result

of trauma. The pathologic process probably differs from that in the juvenile form.

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## CONGENITAL DEFORMITIES— PART I

**Madelung's Deformity**—This uncommon subluxation of the wrist wherein the radius is curved forward and the ulna tends to displace dorsally is of undetermined origin though probably some disturbance of epiphyseal growth in the radius is the underlying factor. Trauma accidental or occupational as in laundresses or clarkwomen is sometimes noted. Roentgenograms confirm the diagnosis.

**Treatment**—In mild cases a leather wrist support suffices. In moderately severe forms a cock up splint to the wrist leaving the fingers and thumb free is necessary. In severe cases operative shortening of the ulna and the restoration of the normal joint alignment may be required.

**Congenital Clubfoot**—Talipes equinovarus is often associated with other abnormalities especially spina bifida occulta. Contractures secondary to an asymmetrical development of the innervation to the muscles of the leg and muscular imbalance are a more potent cause for this condition than mechanical malposition in utero. The bones become molded and fibrous tissues also become contracted. The deformity consists of plantar flexion of the foot on the leg—

equinus inversion of the foot—varus and usually adduction of the forefoot. Torsion of the tibia and knock knee develop gradually in untreated cases.

*Diagnosis* is self evident in the newborn but in older patients similar deformities acquired as the result of paralysis, trauma and other causes must be excluded.

*Treatment* should be instituted as early as possible, preferably on the third day of life, because the muscles and ligaments must be stretched and the tarsus molded while they are still very pliable. The deformity must not only be corrected but completely overcorrected. The overcorrection must be maintained in order to allow adaptive changes in the bones and ligaments to occur and to permit the muscles to build up sufficiently so as to maintain the overcorrected position. Finally, until active use in the normal position is possible, a relapse must be most carefully prevented, as the tendency of a clubfoot to revert is strong and persistent. In infancy, gentle manipulation of the foot followed by the application of a light, carefully padded plaster cast to retain the correction obtained is the method of choice. Removal of the cast in three days allows manipulation of the foot again in order to obtain further correction; this gain is held by another cast. Repetitions of manipulations and the applying of casts allow the foot to be first corrected and then overcorrected without seriously traumatizing any of the tissues or endangering the circulation.

The vessels to the foot are stretched just as much by the manipulations as are the muscles and ligaments, and therefore manipulations must not be too violent. The toes must be carefully watched while in the cast for signs of swelling or an embarrassed circulation. Usually in from two to six weeks full overcorrection of the foot into a position of abduction, eversion and marked dorsiflexion can be accomplished. Then this position is held for a few weeks, and finally a light clubfoot brace is applied to hold the foot in full correction. A relapse must be prevented by bracing until the patient is actively walking. Then shoes with a corrective "dutchman" shall replace the former apparatus. It is often necessary to have the patient wear a brace at night in order to guard against relapse.

An improvement in the conventional manipulation and plaster cast method was introduced by Denis Browne of London who straps the feet to separate skates or heel shoes and attaches the skates in gradually increasing degrees of external rotation to a metal cross piece 8 to 12 inches long. Active movement of the limbs when so fixed produces a sort of self manipulation and corrects both the equinus and the varus elements of the deformity without the stiffness complicating casts or other fixative measures.

The correction of the deformity becomes increasingly difficult as the child grows older, and after six months of age forcible wrenching or tenotomies are often needed to supplement manual stretching. After five years of age it is sometimes necessary to resort to osteotomies to remove bony blocks that prevent correction of the deformity. The more radical measures result in some permanent damage to the foot as a mobile mechanism and are a high price to pay for delay in treatment. However, even the extreme deformities seen in adults can be corrected by operative means, though much of the mobility of the foot must be sacrificed in the correction.

*Coxa vara* exists when the angle of the femoral neck with the shaft is materially reduced below the normal 125 to 130 degrees. It is rarely congenital but usually acquired as the result of trauma, epiphyseal slipping, Legg's disease, fractures with malunion and diseases which cause softening of the bone such as rickets, osteomalacia, osteitis fibrosa, Paget's disease, etc. There is usually considerable torsion of the neck as well as the downward bending, often the pelvis tips forward and the lumbar lordosis is increased.

The *symptoms*—a limp, lameness and an inability to abduct the thighs. The *signs* include shortening of the leg, if unilateral; a marked diminution of Bryant's line with a high and prominent trochanter and loss of abduction, rotation and extension of the hip. In severe cases the mechanical disability in the hip is so great that the symptoms and signs of joint irritation and muscle spasm are found. A *differential diagnosis* between coxa vara and inflammatory lesions such as tuberculosis is made roentgenographically. *Treatment* depends on the age of the patient and the underlying cause. In young children

with soft bones, manipulation and fixation in forced abduction followed by protection against weight bearing is advised. In early epiphyseal slipping at adolescence, manipulation and fixation is again useful. In adults, or in cases in which the deformity has been of long duration, corrective osteotomy just below the trochanter allows correction. The underlying cause must be discovered and treated, or recurrence is certain.

**Coxa valga** is just the opposite of coxa vara. In this deformity the angle of the femoral neck with the shaft is 150 degrees or more. As weight bearing is the force which causes coxa vara, so a lack of normal weight bearing is the most important factor in coxa

fancy the luxated femoral head is opposite the acetabulum but not firmly engaged in it. With activity the head moves freely, and as weight bearing begins, dislocation upward and backward starts. The head carries with it the stretching capsule and ligamentum teres. The dislocation increases until the head comes to be in contact with the ala of the ilium, where it may eventually hollow out a false acetabulum. The true acetabulum fails to develop, and its shallow cup may be filled with fat and fibrous tissue. The head of the femur becomes irregularly flattened and the neck shortened and twisted as its abnormal contacts mold it. The elongated capsule often becomes contracted to an hour-



Fig. 253—Untreated bilateral congenital dislocations in adult showing late bone changes in the femurs, acetabulums, iliums and pelvis

valga. It is found in paralytic conditions especially, though it is curiously enough seen in rickets also. It is not in itself a serious deformity, like coxa vara, but will usually disappear spontaneously if normal functional use of the leg can be restored.

**Congenital dislocation of the hip** is a common and serious malformation. It is more common in certain districts of Europe than in this country and is very rare in the colored race. Eighty-five per cent of cases occur in females. It may be single or bilateral. A large majority of the single cases occur in the left hip. The cause of the deformity is as yet undetermined, but heredity is certainly a factor. Unlike most congenital deformities, it is not recognizable at birth. In early in-

glass shape, and the long muscles of the thigh shorten. The upward thrust of the limb posteriorly tips the pelvis forward markedly, and extreme lumbar lordosis results. These changes take place rapidly after the child starts walking, so that the condition usually is noticeable at an age of from fourteen to eighteen months.

The *symptoms* are a limp if unilateral; a waddle if bilateral. There is no pain during childhood. The *signs* include shortening of the leg with a riding of the trochanter above Nélaton's line; a widening of the perineum, Trendelenburg's sign—a dipping of the pelvis to the opposite side when weight is borne on the dislocated hip; and lumbar lordosis. The *diagnosis* is indicated by the aforemen-



tioned signs coupled with free mobility and no protective muscle spasm despite marked limp. Roentgenograms confirm the diagnosis. *Treatment* consists of manipulation under anesthetic as introduced by Lorenz and modified by Denuec and should be started as soon as a diagnosis has been made. Delay only increases the displacement and distorts the contours of both the head and the socket. A few weeks of preliminary traction may aid in stretching the contracted long muscles and make manipulation easier. Violence must be avoided or damage to the growing femoral epiphysis results. Reduction can usually be obtained by following Denuec's technique but the great difficulty is to prevent redislocation. After reduction a plaster fixation is required for from six to eighteen months to allow shortening of the stretched capsule and deepening of the acetabulum from pressure by the head. Redislocation is usually caused either by an inadequate rim of the acetabulum or by interposition of an hour glass capsule between the socket and the head as reduction is attempted. Every passing year beyond two years of age doubles the difficulty of reduction and after eight years of age manipulations are practically useless.

If manipulation fails or redislocation occurs, open reduction is indicated. When even operation fails to restore and maintain normal relations a false acetabulum may be made or deepened and a bony flap turned down from the wing of the ilium to give a shelf against which the body weight can be stabilized.

In adult cases in which both the dislocated hip and the extreme lumbar lordosis result in severe pain and disability, arthrodesis of the hip may be done in unilateral cases.

**Congenital wryneck, or torticollis**, is usually due to contracture of the sternocleidomastoid muscle, though occasionally bony abnormality causes a severe and intractable deformity. The muscle may become contracted in utero or may undergo fibrosis and shortening secondary to stretching and tearing during delivery. In many cases a hematoma in the muscle can be palpated in the first week. The contracted muscle tilts the head to the affected side and turns the chin to the opposite side. Asymmetry of the head face and spine and even of the shoulder and

thorax results in uncorrected cases. There are no symptoms or signs other than the deformity.

The *diagnosis* is not difficult to make but it is important to differentiate the congenital type from the type acquired secondary to inflammatory lesions (tuberculosis) of the cervical spine, cervical lymphadenitis, arthritis, infectious or post-traumatic, extravasation, etc. In the latter only the exciting cause should be treated actively while in the congenital cases the muscle itself must be attacked.

*Treatment*—In early infancy the deformity may be overcome by gentle stretching, massage and the use of sand bags to hold the head straight. In older cases manipulation and exercises plus bracing may be sufficient for mild contractures but as a rule release of the contracture by operation is necessary. The muscle may be freed either from its origin or from its insertion; the head can then be overcorrected and fixed in plaster until healing occurs in the stretched position.

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## CONGENITAL DEFORMITIES— PART II

**Congenital clubhand** is usually accompanied by a defective development of the bones of the forearm. The deformities of the hand may be forward, backward or lateral or a combination of these. The simple clubhand is somewhat similar to clubfoot and the condition is assumed to be caused by malposition in utero. There may be other congenital deformities present. The second type of clubhand is associated with congenital contractures and other deformities (Fig. 254). The type most often seen is associated with an absence or a defective development of the radius and the hand assumes a right angled relation with the ulna. In the simple clubhand early manipulation and retention of the hand in the overcorrected position by splints is indicated. Massage is given to overcome contraction and to restore good circulation. In the second type, when the condition is associated with deformity of the bones of the forearm, the outlook for correction of the hand is extremely poor and simple procedures to maintain as much use of the hand

which are caused by osteocartilaginous bodies. Injury of the ligaments especially of the crucial ligaments is more common than is generally supposed in mechanical derangements of the knee and examination as to the integrity of these ligaments should be made in every case. Many of the unsatisfactory results which occasionally follow removal of fractured menisci are the result of injury of the crucial ligaments usually the anterior, which is not recognized before operation and failure to secure complete recovery is wrongly laid to the surgical treatment. (See section on Ligaments.)

### THE SEMILUNAR CARTILAGES

The internal semilunar cartilage is somewhat C shaped and rests on the inner tuberosity of the tibia; the external semilunar cartilage is more nearly circular and rests on the outer tuberosity of the tibia. Both serve to deepen somewhat the cavities for the reception of the condyles of the femur. They are fibrocartilaginous in character and do not cast a shadow in roentgenograms except in rare instances when calcium is deposited in their substance. Owing to their fibrocartilaginous nature they tear in their long axis rather than fracture transversely. This peculiarity accounts for the varied types of fractures which are encountered. The internal semilunar cartilage has a firm attachment to the capsule of the joint whereas the external cartilage is more loosely attached a point to be remembered for it has an important bearing on the pathologic changes which are present in derangements of the respective cartilages.

Injury to the internal meniscus is eight times more common than injury to the external meniscus although some authorities place the ratio as low as 4 to 1 or 5 to 1. The chief reason for this fact is the firm attachment of the internal cartilage to the internal capsule really the internal lateral ligament. The external cartilage is loosely attached to the external capsule and thus has a certain amount of mobility which allows it to slip from between the ends of the bones when it is caught. This is not true of the internal cartilage for it is so firmly attached to the lateral capsule that it will rip or tear in its own substance rather than break loose from its moorings.

### TRACTURES OF THE MENISCI AND THE MECHANISM OF PRODUCTION

The menisci lie well toward the peripheral margin of the joint away from the bearing surfaces and normally offer no obstruction to motion. Inasmuch as the internal semilunar cartilage is most often fractured discussion will be confined chiefly to it. This cartilage is most deeply placed within the joint when the knee is partially flexed and the foot everted in which position the head of the tibia is rotated outward slightly on the femur. If this position of eversion of the foot with consequent outward rotation of the tibial head is maintained as the act of extension is carried out the inner condyle of the femur may roll down on the internal meniscus and grip it. Unless the act of extension is stopped in time one of two things must happen either the internal semilunar cartilage must be torn from its moorings and dragged toward the center of the joint or it must tear in its substance. The latter is what actually occurs. The exact location of the tear or fracture in the meniscus will depend on the point at which it is nipped. It may be in the anterior middle or posterior portion. The force causing the derangement may be so great that the blocking action which culminates in the final giving way (fracture) of the meniscus will not be sufficient to check it and continuation of the force may drive the knee into hyperextension and rupture the anterior crucial ligament. When the anterior crucial ligament is so ruptured the tibia slips forward on the femur, and an unstable knee results. This hypermobility is rarely marked but it can be detected by having the patient sit on a hard chair or table and allow the leg to dangle over the edge in such a manner that the knee is flexed at a right angle if the head of the tibia can be pulled forward appreciably on the femur it is evidence of a rupture of the anterior crucial ligament. Persons differ in the amount of mobility which is normally present therefore the affected knee should be compared with the sound one. Operations for repair of this ligament have been devised but are seldom indicated.

**Symptoms and Diagnosis.**—Injury of one of the semilunar cartilages occurs generally among males who are in the active period of life and engaged actively in work

or games. On the other hand it may be independent of any unusual activity and it has been known to occur while the patient is recumbent in bed when locking of the joint results merely from turning over. The event in any case is accompanied by pain by inability to extend the knee and by swelling. Pain is usually located on the side of the involved cartilage but not infrequently the pain is described as generalized. The knee is held in partial flexion (locking) but may be released and straightened by the active efforts of the patient himself or someone may pull on the leg for him and it will

gradually grind the obstructing portion of the cartilage to such fine shreds that no obstruction finally is offered. On close questioning of the patient it is almost uniformly discovered that at the initial attack particularly when the internal meniscus is concerned the knee was partially flexed the foot was abducted and rotated outward thus throwing the strain on the internal lateral ligament and as the act of extension continued the catching occurred.

In the majority of instances of derangement of the knee joint that are the result of injury of the semilunar cartilage a tear or

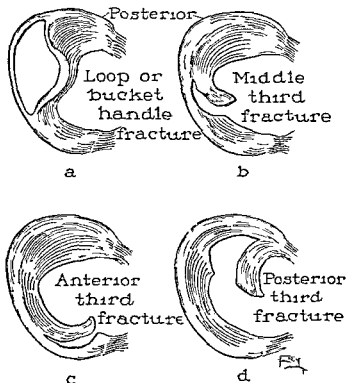


Fig. 5.—Types of fracture of internal semilunar cartilage

straighten often with an audible snap. Usually recurrent lockings ensue and their irregularity makes steady employment difficult. Although the attacks may increase in frequency, the tendency is for the pain swelling and period of incidental disability to decrease. An actual fracture or tear in the meniscus may not be produced at the initial attack but as the attacks recur with catching and squeezing of the cartilage between the ends of the bones, a fracture is usually produced. Sometimes when the condition affects vigorous men who pay little attention to pain the repeated lockings

fracture will be discovered in the meniscus which is involved. However a cartilage may be hypermobile as the result of a lax capsule so that it occasionally will be caught and pinched between the ends of the bones but it will not be actually fractured. The most common type of tear or fracture is that which has been called a bucket handle fracture or loop fracture. This is a longitudinal tear in the middle portion of the cartilage leaving the anterior and posterior ends intact so that the mesial portion of the cartilage is crowded over into the intercondylar notch in the form of a loop (Fig. 255). The

mesial portion of the loop of the cartilage in this position obstructs extension and full flexion usually cannot be attained. This type of fracture occurs in both the external and internal semilunar cartilages. There are other common types of tear or fracture of the cartilage (Fig. 255). The more common types are (1) the bucket handle fracture, (2) the longitudinal pedunculated flap with its base either forward or posterior in the anterior third and (3) the tears in the middle and posterior thirds which likewise have their bases either forward or posterior (Fig. 255). The latter may produce bizarre symptoms of transient catching. Effusion varies in individual cases.

A bucket handle tear which is caused by the primary injury may have such a large thick loop lying in the intercondylar notch that the knee cannot be straightened even by manipulation under anesthesia. The loop may persist thus for months, all swelling and pain may leave and the only symptoms may be a feeling of insecurity and inability to extend the knee completely. In these rather rare instances removal of the cartilage is indicated even though there has been but the single attack. The patient may note the lack of extension only when told to stand erect with the feet together and to straighten both knees.

**Differential Diagnosis.**—Arthritis either tuberculous or infectious may produce swelling and edema of the synovial membrane, little foci of synovia may be nipped between the bones but the pain which results from this pinching is not severe. One should be cautious about making a diagnosis of mechanical derangement of the knee joint when a thickened capsule is present and particularly if other joints give evidence of arthritis.

Recurrent dislocations of the patella which usually affect women are also sudden in onset and painful but the patient as a rule observes that the patella is displaced outward. Sometimes a definite diagnosis is difficult and under such circumstances surgical intervention should be postponed meanwhile the patient should be asked to note carefully the subjective and objective symptoms which occur during the next attack.

**Conservative Treatment.**—When one

first examines a patient with a mechanical derangement of the knee joint which is the result of an injury to the internal semilunar cartilage the knee should be manipulated and straightened. This may be done without anesthesia in many cases. The patient should be recumbent preferably on a low, flat firm table and the knees should hang over the end. The surgeon stands between the patient's legs and flexes the affected knee as fully as possible holding the patient's ankle firmly in one hand while the thumb of the other hand presses over the anterior end of the cartilage which is involved. With the cooperation of the patient and at the count of three the knee should be forcibly extended and at the same time the tibia should be rotated inward. This movement tends to release the torn or fractured portion of the cartilage. If the knee goes into complete extension and the patient says that the knee feels right all is well but if this reassurance on the part of the patient is lacking the probabilities are that reduction has not been accomplished and that the maneuver should be repeated. If neither surgeon nor patient is satisfied the chances are that a bucket handle fracture is present and that the loop is held firmly in the intercondylar notch. If reduction is satisfactory a posterior splint should be applied; this should be worn for ten days or until all soreness and swelling have subsided. Diathermy or radiant heat may hasten absorption of the effusion. If the cartilage was merely pinched and not fractured subsequent locking may not occur but if there was a fracture attacks of locking almost certainly will follow, and removal of the offending meniscus will be necessary. If reduction was not accomplished satisfactorily the patient should be put to bed and the leg should be held as nearly straight as possible in a comfortable position. Heat of folds relaxation and as the swelling subsides the knee may straighten of its own accord without the act of reduction being definitely noted. If it stays locked exploration is advisable.

**Surgical Treatment.**—More than a single locking should have occurred before one resorts to surgical treatment save in the exceptional cases which have been mentioned.

The utmost care must be used in establishing a definite diagnosis as to which men-

iscus is involved for there is no single incision that gives free opportunity for exploration of both. Even an extensive longitudinal split patellar incision does not do it and this is now used by very few surgeons. Generally speaking if the internal meniscus is involved the pain extends to the inner side of the knee and if the external meniscus is the offender the opposite is true. Pain is caused by tension on the capsule and ligaments not by the pressure on the meniscus or joint surface. It is possible though not common for a fracture of an external cartilage so to distort the joint that pain is referred to the inner side of the knee. The roentgenogram is of no aid because the meniscus casts no shadow.

The preparation of the knee for operation is important. Infected abrasions and pustules in the skin are dangerous and no knee joint should be opened when they are present. The leg should be cleansed with soap and water at the time of shaving and a sterile bandage should be applied but the actual preparation may be done on the operating table. No more care is necessary here than is required in the preparation for any other operation, there are no grades in preparation but the exact method that is employed depends on the choice of the individual surgeons. After adequate preparation of the skin the leg is properly draped a tourniquet is applied the foot of the operating table is dropped and the patient's leg is allowed to hang over the edge of the table at a right angle. The skin incision for removal of the internal meniscus need not be long about 5 cm. in length is sufficient it begins 1.5 to 2 cm. to the inner side of the patella and extends downward from the level of the middle of the patella to a little below the level of the head of the tibia.

If a fracture is present in the cartilage as much of the torn portions of the cartilage as possible should be removed three fourths is usually sufficient and care must be taken not to injure the internal lateral ligament. If no fracture is discovered the patellar tendon should be pulled forward with the aid of a smooth retractor so that one may look across into the external compartment of the joint to see if the external cartilage is injured. This method of exploration of the external compartment is not really satisfactory

however and if no abnormality has been disclosed and if the symptoms warrant it, a separate external incision should be made. If no abnormality is seen and if the history of recurrent locking with pain which extends to the inner side of the knee is definite the internal meniscus may be removed if the surgeon feels that the disability is great enough to warrant it. Occasionally when the anterior portion of the cartilage is loosened and the meniscus pulled forward a fracture will be found in the posterior third which could not have been determined in any other way. If the posterior portion of the cartilage must be removed a posterolateral incision which is made just anterior to the hamstrings is particularly useful especially in those cases in which a lesion of the posterior third of the cartilage is suspected and in which its removal is deemed necessary. The capsule of the joint should be closed in layers and the knee should be put up in extension either on a posterior splint or in a plaster of paris cast which is split. If the external cartilage is to be removed a similar incision on the outer side should be employed. Unless there is considerable effusion the cast may be removed after five days and gentle movement permitted. If all is well the patient may be permitted to bear weight and walk eight to ten days after the operation.

### OSTEOCARTILAGINOUS BODIES

Osteocartilaginous bodies cause derangements of the knee that are less severe than are those which are the result of disturbances of the semilunar cartilages. Sometimes the patient himself is able to palpate and localize the bodies and they are always visible in roentgenograms. In rare instances the derangement is the result of involvement of both a semilunar cartilage and the osteocartilaginous bodies. The bodies may be entirely free and may wander about the joint they may become smooth and rounded they may be attached by a pedicle to the synovial membrane or they may be held enfolded in synovial membrane. In the latter case they are rougher and mulberry like in appearance. The chief interest surrounding these bodies concerns their etiology and they are best classified under three headings.

1. Some osteocartilaginous bodies are the

result of *osteoarthritis* and usually affect persons who are beyond middle age. The bodies originate from the marginal osteophytic growths which do not break off completely at first but remain attached for a time by a pedicle that contains blood vessels. These bodies increase in size and finally break away from their pedicles to wander as free bodies in the joint. While the body is attached by a pedicle the bony substance may increase but this ceases after the body breaks away from the pedicle; however the joint fluid affords sufficient nourishment for the outer cartilaginous layer to increase in thickness. In *osteoarthritis* the bodies are multiple; there often are as many as five or

symptoms may be indefinite and the patient may have a feeling of insecurity in the knee. The patients are usually in young adult or early middle life. Roentgenograms should be carefully studied to detect any abnormality on the surface of the internal condyle.

3 Loose bodies which are the result of *osteocondromatosis* may be quite numerous and may cause the knee to feel like a sack of marbles (Fig. 257). *Osteochondromatosis* is in reality a benign neoplastic process which produces osteocartilaginous bodies particularly at the attachment of the synovial membrane to the bone but they may arise from any area of the synovial membrane. The bodies first appear as little fleshy nodules



Fig. 256



Fig. 257

Fig. 256—Loose body in *osteoarthritis dissecans* arising from the internal condyle.

Fig. 257—*Osteochondromatosis* of the knee with multiple loose bodies.

six. Patients in this group are usually elderly and unless the bodies are causing discomfort they may be left.

2 Loose bodies may be the result of *osteocondritis dissecans*. This is a rather unusual condition that deserves a more lengthy consideration than can be included here. The bodies are formed as the result of separation of a piece of osteocartilaginous substance from the articular surfaces of the knee usually from the internal condyle of the femur just proximal to the insertion of the posterior cruciate ligament into the internal condyle (Fig. 256). The bodies are usually single and both knees are occasionally involved. The body may arise from the external condyle, the tibia or the patella. While the process of separation is going on, the

bodies become cartilaginous at the tips; they grow in size and hang into the cavity of the joint by pedicles which break as the bodies become too heavy. Several cases have been reported in which the bodies exceeded a thousand in number.

Symptoms—Regardless of the origin of the bodies, the symptoms which they produce are the same, namely, catching or locking of the joint with pain. Swelling rarely follows and the pain is of short duration. In young persons the presence of these bodies *per se* is sufficient indication for their surgical removal but in elderly patients as has been mentioned previously they may be left undisturbed. Removal of such bodies should be done under the strictest aseptic conditions. Too often removal of these bodies

in the office has led to seriously infected joints with dreadful sequelae.

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### AMYOTONIA CONGENITA, CEREBRAL SPASTIC PARALYSIS, SPRENGEL'S DEFORMITY, POLIOMYELITIS

#### AMYOTONIA CONGENITA

(*Oppenheim's Disease*)

**Definition.**—A congenital weakness of muscle, local or general, characterized by hypotonus and flabbiness.

**Etiology.**—The etiology is congenital, otherwise unknown.



Fig 258—Amyotonia congenita (New England Peabody Home case)

**Pathology.**—The muscle fibers occur in clusters. Some are small and fetal in type, and others are increased in size.

**Symptoms.**—Generalized weakness and loss of tone in local groups of muscles or involvement of practically all the muscles of the body are symptoms of this disease.

There is not complete loss of power. The reflexes are absent. The disease resembles in some respects a generalized poliomyelitis. Contractures occur in the extremities.

**Treatment.**—Treatment includes physiotherapy, the avoidance of fatigue and the correction of contractures by stretching, tenotomies or fasciotomies as indicated.

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#### CEREBRAL SPASTIC PARALYSIS IN CHILDREN

(*Little's Disease*)

This affection is not a true paralysis but rather an increase in muscular tone due to a loss of inhibitory control in the central nervous system. It is characterized by disturbances in locomotion from exaggerated muscle movements. The affection may be confined to one extremity, monoplegia, one side of the body, hemiplegia; two extremities, paraplegia, or both sides of the body, diplegia.

**Etiology.**—This disease is probably due chiefly to developmental defects in the central nervous system. Prolonged or precipitate labor with damage to the brain from hemorrhage and bad obstetrical technic or asphyxia are also considered from an etiological standpoint.

**Pathology.**—The lesion is situated in the motor area of the brain, sometimes associated with hemorrhages in the basal ganglia. As a result, there are disturbances of development, atrophy of brain tissue, sclerosis and sometimes calcification, and also degeneration of the pyramidal and lateral tracts of the cord.

**Symptoms.**—The symptoms depend on the extent of the lesion and the amount of disability. The muscles show increased tone on palpation. Small children react very suddenly, with dissociated movements, to sudden noises. Active muscular efforts increase the spastic movements, and walking and the use of the hands show slight impairment of function up to complete inability to do anything. In the monoplegic type there is an

equinus with a clinging gait in walking. In hemiplegia the arm is held flexed at the wrist, fingers and elbow, the forearm is pronated and the shoulder is adducted. In paraplegia, which is the most common form, there are the symptoms seen in monoplegia plus a scissors gait. The knees and hips are adducted and internally rotated. In diplegia there are the symptoms of hemiplegia on each side. Exaggerated reflexes and clonus are important symptoms. The deep reflexes are increased and the Babinski and Oppenheim reflexes are often present. At times the

true  $\kappa$  the mental development may be above normal.

**Diagnosis**—The diagnosis is based on the general picture and should not be difficult even in the mild cases if a careful examination is made.

**Prognosis**—The prognosis depends on the extent of the lesion in the extremities and the mental status. Extensive athetoid movements make the prognosis poorer since it is much harder for those so affected to control their movements.

**Treatment**—The treatment includes (1) testing the mentality of the patient, (2) removing all sources of outside irritation, (3) using good discipline and (4) avoiding fatigue.

If the mental retardation is not too great and one can expect cooperation from the child and his parents, then one may outline a plan of treatment suitable to each individual case. It is well before considering operative measures to begin by using proper physiotherapeutic exercises in muscle re-education, balance, coordination and rhythm. Massage and electricity aggravate an irritable limb and serve no good purpose. All sorts of devices can be used to stimulate the function of the affected muscles.

The different forms of *operative treatment* are divided into two groups: (1) operations on the muscles in which myotomy or tenotomy is done and tendon transplantation, (2) and operations on the nervous system—*infiltration of nerves with alcohol*, *section of motor nerves* (Stiffel's operation), *division of posterior nerve roots* (Forster's operation) or *ramisection* (Rosie).



Fig. 259.—Spastic paralysis. Diplegia, crouching position (Cleveland Hospital case).

hypertonicity in all the muscles is so great that the reflexes are not obtained at all. The gait may be ataxic with a lack of rhythm, coordination and balance.

Athetosis is often seen associated with the spastic condition. These athetoid movements are dissociated, occur involuntarily and are always exaggerated when the patient attempts to perform some act. A generalized athetosis may exist alone. Many of these patients are labeled as mentally retarded when such is not the case. Mental retardation is often seen, however, in true spastic paralysis and sometimes the contrary is



time the biceps tendon is divided. If there is bony obstruction to complete extension an osteotomy should be performed. In many instances the patella is higher than normal. In case this is so it will be necessary to insert the patellar tendon down on the tibia, using skeletal traction by means of a pin through the patella and incorporated in the plaster and left for three weeks. Unless this is done the patient will not have power enough in the retracted quadriceps muscle to extend the knee completely. The leg should be kept extended after these operations for from six to eight weeks in plaster.

**Adduction contracture** may be relieved by dividing the adductor muscles completely. The legs must be kept abducted for from eight to twelve weeks in a plaster spica. If there is much abductor weakness Legg's operation should be done. This operation consists in freeing the tensor fasciae latae from its surrounding structures and transplanting the upper portion which has been freed to a place more posterior so that it acts as a pure abductor. This operation also helps to remove inward rotation and hip flexion contracture.

**Scalosis** is usually due to muscle contracture of the spinal and lateral abdominal muscles and may be relieved by dividing the lumbar fascia and the shortened intermuscular septa in this region.

**Flexion and Adduction of the Hand**—The flexor carpi ulnaris may be transplanted into the dorsal surface of the base of the third metacarpal bone relieving the adduction and assisting dorsal flexion. In pure flexion deformity tenodesis of the extensor carpi ulnaris to the ulna and of the extensor carpi radialis brevis to the radius holding the hand in the cosmetic cock up position will improve the function of the hand tremendously. The hand must be kept overcorrected for six weeks.

**Pronation contracture of the forearm** necessitates a Jones operation. The pronator radii teres tendon is completely freed from its insertion and sutured as low down as possible into the two radial extensors. The wrist is kept dorsiflexed.

**Adduction contracture of the shoulder** may be relieved by section of the pectoralis major and subscapularis tendons.

**Operations on the Nervous System**—1. Infiltration of the motor nerves with strong alcohol results in temporary paralysis which lasts for from six to eight weeks. This procedure permits one to carry on physiotherapy to a better advantage since the contracted muscles do not function.

2. Section of the posterior nerve roots or Forster's operation consists in division of the third fourth and fifth lumbar and the first and second sacral dorsal roots to relieve spasm in the lower extremity and the division of the last four cervical and first thoracic roots to relieve spasm in the upper extremity. This operation is very severe on the patient and is practically never done in this country for this type of paralysis.

3. Division of motor nerves. Stoffel's operation consists in resection of at least 2 inches of a motor nerve that goes to a spastic muscle. It has been performed on the internal popliteal nerve for equinus the sciatic branches to the hamstrings the obturator and the

median nerves. The results on the first three nerves are not as successful in general as they are on the obturator and median nerves. Resection of the anterior cord and the median nerve is excellent in cases of pronation spasticity. The proximal portion of the cut nerve should be sutured to the fascia so as to prevent regrowth.

4. *Non-resection of sympathetic nerves* as advocated by Royle has not been generally successful. In cases of increased spastic tone it does seem to be helpful and it also increases the surface temperature of the extremities.

5. Section of the anterolateral tracts is advocated by Putnam in cases of athetosis. Marked improvement results in some cases.

**Summary**—There are numerous operations advocated in the management of spastic paralysis but none of them cures the condition. The whole object is to remove deformities and disabilities in order that one may proceed with the real treatment which is physical education. Each individual case must be considered from the physiologic aspects of the neuromuscular mechanism. These patients must be taught how to relax. The exercises given must be simple and since the spastic attitude is that of protection, it is necessary to attack the extensor muscle groups.

Most of these patients are lacking in balance, rhythm, precision and coordination. To obtain the desired improvement in these conditions means treatment over a long period and requires gentleness and patience on the part of the physiotherapist.

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## SPRENGEL'S DEFORMITY

### (Congenital Elevation of the Scapula)

This type of congenital deformity is an upward displacement of the scapula. It is usually unilateral but bilateral lesions are seen occasionally.

**Etiology**—It is a primary deformity and other primary deformities also may be present.

**Pathology.**—The scapula is smaller than its fellow. The supraspinous area is hooked sharply forward. Four types may be found: (1) the type in which there is no connection between the scapula and the spine, (2) the type in which there is a fibrous band extending from the vertebral end of the spine of the scapula to one of the cervical spines, (3) the type in which there is a cartilaginous isthmus, and (4) the type which shows a bony isthmus, wide at its base and with a definite part of the scapula extending obliquely upward and forming a fairly solid articulation with the spine.



Fig. 260.—Scapula deformity (Children's Hospital case.)

**Symptoms.**—The scapula is high and rotated forward, making an unsightly prominence at the root of the neck. Torticollis and scoliosis may accompany the lesion. Limitation of abduction and elevation of the arm are usually present.

**Diagnosis.**—The diagnosis is made from a study of the symptoms and is confirmed by the roentgenogram.

**Prognosis.**—If the condition is not treated, it becomes increasingly unsightly. Operative intervention will improve it cosmetically and is nearly always satisfactory.

**Treatment.**—Mild cases are helped by special exercises. The majority, however, are severe, and operation is indicated. There are two objects to be obtained: first, removal of the deforming elements and, second, depression of the scapula.

It has been the custom in many clinics to make an incision parallel to the spine of the scapula, to remove the muscular attachments in the supraspinous area, both anteriorly and posteriorly, subperiosteally, and to divide or to remove connecting falks leading to the spine. In some instances the scapula is pulled down as far as possible and attached to a rib by means of fascia or other suture material. The writer's method is as follows:

1. The deforming elements are removed as previously described except that the muscles are cleared from the periosteum since it has been found that the supraspinous fossa may grow back where a subperiosteal dissection is made.

2. A hole is drilled through the center of the spinous process and a double strand of dental wire is threaded through it.

3. A second incision, 1 inch long, is made 2 inches below the tip of the scapula, and all free ends of the wire are drawn down beneath the muscles of the scapula emerging from the lower wound.

4. A long plaster spine, open at the back of the waist line, is applied to the leg and a ring is attached. As soon as the patient is comfortable, skeletal traction is begun using a spring balance with from 6 to 8 pounds of weight. This is continued until the scapula is pulled down and requires about four weeks. At the end of this period, a 3 inch incision is made over the dorsal spine, exposing the superficial spinal muscles and fascia. A flap of muscle and fascia, 4 inches long with the base down is freed and sutured to the inferior angle of the scapula subperiosteally. This maneuver allows for more flexibility of the scapula and at the same time holds it down.

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## POLIOMYELITIS

### (Infantile Paralysis)

**Definition.**—Poliomyelitis is an acute infectious disease having general constitutional and central nervous system manifestations, usually localized in the anterior horn cells of the spinal cord and often characterized by motor paralysis.

**Etiology.**—The infecting organism is unknown, but recent research has produced strong evidence that a filtrable virus is an

etiological agent. It occurs in sporadic and epidemic forms. There are certain areas where it is practically always prevalent, more especially in the northern part of the north temperate zone. The majority of the cases are seen during the summer months although a few cases appear throughout the winter months.

**Pathology**—The early pathology is a primary invasion of the meninges with perivascular infiltration, hyperemia and edema of the cord. As a result of this inflammatory process the delicate vessels leading to the anterior horn cells and the cells themselves are pressed on, shutting off the circulation and causing chronic and temporary loss of function. If there is no relief from pressure of the exudate, necrosis results and the damage to the individual cells is permanent. The posterior root ganglia are probably always involved. In occasional cases there is similar involvement of the brain medulla and pons. When cells are completely destroyed they are replaced by cicatricial tissue—focal gliosis. Owing to the vertical overlapping distribution of the anterior horn cells it is rare to see a total motor paralysis.

**Symptoms**—There may be no history of early symptoms. A child apparently well may go to bed at night perfectly well and may be found to be paralyzed in the morning. The usual early symptoms are constitutional and include fever, malaise, headache, mental irritability, gastrointestinal disturbances, coryza, pharyngitis and tonsillitis. Quite often there is general hyperesthesia. Photophobia is sometimes noted. Associated with all these symptoms is stiffness of the neck or back, varying in degree from a very mild type to extreme rigidity. Tremor and pain in the extremities are usually present. These symptoms occur in what is known as the prodromal stage, i. e. before the paralysis appears. Lumbar puncture should be performed at this time. Early the deep reflexes may be increased, late they are diminished or lost.

For the sake of clearness, Lovett divided the disease into three stages as follows: acute, convalescent and chronic.

**I. Acute Stage**—The acute stage covers that portion of the disease from the earliest symptoms to the disappearance of the tenderness. Tenderness is probably evidence

that the inflammatory condition in the cord has not subsided.

**2. Convalescent Stage**—There is retrogression of the inflammatory process and if paralysis is present, it is well established. The muscles begin to show improvement and circulatory disturbances and atrophy are more and more apparent. The arbitrary length of this stage is two years, but the writer has seen in many instances a returning muscular function over a long period of years.

**3. Chronic Stage**—Spontaneous recovery has by this time slowed down considerably. Deformities have become more or less permanent and atrophic and circulatory changes are more noticeable.

**Distribution of the Paralysis**—Paralysis which is rarely symmetrical is more often confined to the lower extremities, the anterior tibial muscle being the one most frequently affected—one leg or both either partially or completely. The extensors of the knee are more often paralyzed than the flexors. Those muscles most often spared are the peroneus, sartorius and the tensor fasciae latae. The abdominal muscles are rarely spared and the spinal muscles are rarely affected. The anterior neck muscles are practically always affected even in very mild cases. There is a transitory neck drop in practically all cases. This is not due to paralysis of the neck muscles. Facial paralysis is seen in about 30 per cent of all cases. There may be paralysis of the muscles of deglutition, the soft palate, the pterygoids and respiration. The upper extremities may be totally paralyzed, but the deltoid and opponens pollicis are most commonly affected.

**Sensory disturbances** are sometimes observed but they are evanescent, mild and never permanent. Paralysis of the bladder may be a complication, but complete recovery within six weeks is the rule.

**Tenderness**, often associated with muscle spasm, is noted early when the paralysis is established and may be very severe and even distressing. It does not follow the distribution of the paralyzed muscles for it is seen in an extremity that is otherwise perfectly well. The usual situation of the tenderness is in the calf, anterior thigh, buttock, anterior hip muscles, back and axillary muscles. The tenderness may be so severe that

the child cries at the least jar or movement. Flexion deformities of the legs and adduction of the arms occur as a result unless proper treatment is instituted. The period of tenderness may last for from a few weeks to a year or more.



Fig. 201—Hyperextension of the knees in poliomyelitis. (Children's Hospital case.)

**Diagnosis.**—The diagnosis is missed frequently because the physical examination has been hasty and incomplete. The disease is often mistaken for "acute rheumatism," "grippe," sore throat, "biliousness" or osteomyelitis. Given the symptoms just described the physician should test for stiffness of the neck. He should not be satisfied with mere raising of the head because all the posterior spinal muscles are affected. In a mild case the test must be made with the patient lying on his side and with the whole body, including the neck, flexed. In the presence of a stiff neck or back, lumbar puncture is always indicated. The spinal fluid is usually clear but may show a faint ground glass appearance. There is often increased pressure; the leukocyte count is increased—usually there are mononuclears, but there may be a high percentage of polymorphonuclear cells, and there is an increase in globulin.

**Prognosis.**—In all cases the mortality rate is about 20 per cent in this country. Death is due to respiratory paralysis or pulmonary complications. When recovery takes place the prognosis as to function must be guarded, especially in the tender stage. In

most instances, however, there is practically always improvement and sometimes complete recovery. There is the so-called abortive type which shows the characteristic constitutional symptoms but no paralysis. Shortening of an extremity may or may not occur.

**Treatment.**—In the acute stage the treatment is medical and good nursing is valuable. When there is respiratory difficulty, it may be necessary for the patient to live in a Drinker respirator. Tenderness and spasm are treated by the application of heat in some form, hot saline baths and early frequent applications of hot packs seem to give the best results. (Pohl and Kenny.)

The extremities if paralyzed must be kept on wire splints in the most comfortable position. As the tenderness subsides the splints may be gradually straightened until the extremities are in such a position that no contractures will occur. Massage should not be given during this period.

**Prevention of Deformities.**—The patient should not be permitted to assume positions

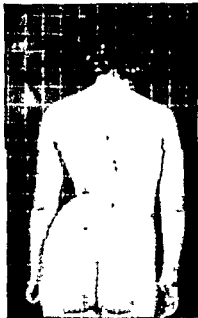


Fig. 202—Scoliosis in poliomyelitis. (Children's Hospital case.)

favoring contractures. Deformities, however, should not be corrected if in so doing the tenderness is increased; otherwise a mild deformity may be converted into a troublesome one. Absolute rest must be insisted on during the acute stage. Any form of treat-

ment at this time such as massage electricity and exercises is meddling and serves to prolong this stage.

**Convalescent Stage**—As soon as it is apparent that all tenderness has subsided measures to rehabilitate the affected muscles may be begun. To this end it is necessary that a complete examination of all muscles be made in order to determine what the physiologic problem is. For clearness it is best to have a chart of all muscles or muscle groups. The paralyzed muscles are graded on the chart according to the following key:

Zero = no power

Trace = slight ability to contract a muscle

Poor = ability of the muscle to move the affected part through its normal arc with gravity eliminated

Fair = power to function against gravity

Good = power to function against gravity plus resistance

Normal = normal function

A record of this type enables one to see at a glance what the physiologic problem is and helps one to meet it intelligently.

Systematic exercises are now prescribed for the affected muscles in order to improve their function. The paralyzed parts must be supported in such a way as to avoid any drag on weakened muscles and to prevent

Early walking must not be allowed unless it is obvious that there will be no return of power and a patient with a severe case practically never should be allowed to walk during the first year unless his morale is being affected by too much rest. Swimming and



Fig. 961.—Opponens pollicis paralysis in poliomyelitis (Children's Hospital case)

exercises in water tanks are very helpful for those who are extensively paralyzed. Massage and the application of heat are of assistance in promoting the circulation and should precede the more active forms of physiotherapy. Electricity has been extensively used but without much success; the principal objection to its use being the inability to measure the dose. It is also a passive form of therapy.

**Chronic Stage**—There is no sharp border line between the convalescent and the chronic stage. The chronic stage is that of residual paralysis, deformities and disturbances in locomotion.

**Locomotion**—A great deal may be learned about the disabilities due to the paralysis by having the patient walk. The type of limp, the deformity and the consequent loss of function may be readily observed.

**Deformities—Feet**—Equinus, foot drop, valgus, varus or calcaneus and combinations of two or more of these.

**Knees**—Flexion, hyperextension, varus and valgus.

**Hips**—Dislocation, abduction, adduction, flexion and rotation. In addition to these conditions there may be shortening and twisting of the leg.



Fig. 962.—Deltoid paralysis in poliomyelitis (Children's Hospital case)

contractures. It is well known that a weak unsupported muscle will steadily lose in power if overused or not protected. Deformities must be guarded against during this stage by suitable apparatus and meticulous attention to posture.

*Spine*—Scoliosis

*Shoulders*—Adduction of the shoulders  
subluxation and prominent scapulae

*Elbows*—Flexion pronation and supination

*Wrists*—Flexion extension adduction  
and abduction

*Fingers*—Extension and flexion

*Thumbs*—Extension and external rotation

These deformities may be apparent or fixed. If fixed, they are due to bony changes and contracted ligaments, muscles and fasciae. When not fixed they are due to overbalance of muscle power or to faulty weight bearing on improperly supported or unsupported extremities. Corrigible deformities must be treated with the proper apparatus. Non corrigible deformities are treated by stretching in plasters or splints or by operations.

*Treatment During the Chronic Stage*—1. *Muscle re-education* must be carried on just so long as there is any indication of improvement and also after operations.

2. *Apparatus*—Braces, plaster casts and splints are used to aid the patient in walking and also in correcting deformities after they have occurred.

3. *Operations*—(a) Operations to improve function are lengthening of tendons and fasciae, and tendon transplantations. (b) Operations to improve stability are tenodesis, astragalotomy, arthrodesis and pan arthrodesis.

*Simple equinus can be an asset and not a liability*, since its mechanical action assists in locking a paralyzed knee joint, thereby permitting the patient to walk without a long brace. In many instances it is necessary to relieve a permanent equinus by the application of plaster from the toes to the knee. Straps and buckles are incorporated in the plaster when it is being applied and an orange-peel section is removed from the dorsal aspect of the ankle. Gradual tightening of the straps will often relieve the equinus. In cases of persistent equinus it may be necessary to lengthen the tendo achillis; this should always be by open operation. The tendon is divided by a long oblique or Z type of incision and carefully sutured after the condition is corrected.

Subcutaneous tenotomies may fail to unite

and may result in flat foot or a bad calcaneus.

*Tendon transplantation* has a wide application in both extremities. The following are the main requirements for successful tendon transplantation.

1. Rigid asepsis
2. Selection of a suitable case
3. Sufficient power in the transplant to secure good function
4. A minimum amount of handling of the tendon
5. The direction of the transplant to be as nearly as possible in line with the muscle it is to replace
6. The carrying of the transplant beneath the deep fascia when possible
7. Bone insertion (this is desirable in the lower extremity)
8. Removal of a fixed deformity by a primary operation or at the same sitting
9. Transplantation of tendons under moderate tension
10. Heavy silk to be used for the insertion (this is the most dependable material)
11. Attention to leverage (this is important)
12. Overcorrection of the deformity

In children over seven years of age transplantations in the foot are more satisfactory when combined with some stabilizing operation. However in order to avoid severe deformity, it may be wise to transplant early and delay the stabilizing procedure until the bones are less cartilaginous in structure.

**Operations to Improve Stability.**—*Tenodesis* was originated by Codavilla and later improved by Gallie. It is more successful in adults with foot drop, valgus or varus. It consists in suturing the distal end of a divided tendon or tendons to the bone proximal to the deformity.

*Astragalectomy* Whitman's operation is indicated in flail feet and in severe calcaneus but has been largely superseded by arthrodesis.

*Arthrodesis* is designed to secure stability with a minimum loss of motion (Hoke and Ryerson). It is best combined with tendon transplantation when possible since the stabilizing factor permits the transplanted tendon to function more strongly in its new position. This operation has been refined so that it is applicable in flail foot equinus and calcaneus deformities (Brewster advocates countersinking the astragalus Campbell a posterior bone block for equinus and Putti an anterior bone block for calcaneus).

*Pan arthrodesis* is reserved for flail feet. The astragalus is arthrodesed to the tibia calcaneus and navicular bones.

**KNEE.**—*Flexion* of the knee is due to contracture of the hamstrings and may be corrected by the application of a plaster cylinder extending from the ankle to the groin. This is divided posteriorly leaving a short isthmus of uncut plaster over the patella. From day to day wedges are inserted at the back of the plaster until the knee is straight.

*Knock knee* may be corrected manually under an anesthetic if the bones are atrophied. The fracture usually takes place just below the tibial tuberosities and is incomplete without displacement of the fragments. If the bone is hard it will be necessary to divide it with an osteotome just below the head of the tibia. The deformity is overcorrected and the fractured ends are impacted. Performing an osteotomy below the joint instead of above allows the surgeon to apply a leg cast instead of a spica.

*Hyperextension* is due to weakness of the hamstrings or of the gastrocnemius muscle or to permanent equinus. This may be relieved by attention to the equinus if present and by tenodesis of the iliotibial band or the biceps tendon to the femur. The inner hamstrings also may be used.

**Tendon Transplantation of the Knee.**—This operation is indicated in paralysis of the extensors or flexors. To relieve a paralyzed quadriceps the biceps femoris is often used also the sartorius and the iliotibial band singly or in combination. The insertion is made on the bare surface of the patella and the tendons are sutured to the ligamentum patellae and the aponeurosis. If there is weakness of the hamstrings the iliotibial band may be transplanted posteriorly into the split biceps tendon and the posterior aspect of the fibula.

**Hip.**—*Flexion* is the most common deformity. It may be relieved by Soutter's operation which consists in dividing the fascia lata opposite the anterior superior

spine laterally and stripping the muscular attachments from the anterior, lateral and medial aspects of the front of the iliac crest, anterior superior spine and interspinous notch. Yount advocates division of the iliotibial band just above the patella.

In an early case the deformity may be stretched gradually by the use of a raised frame and casts applied to the leg allowing the weight of the legs to stretch out the contractures. Associated with a flexion deformity there is often weakness of the gluteus maximus and sometimes if location occurs. The iliotibial band may be stripped upward and the lower end transplanted to the erector spinae muscles. If the acetabular shelf is too shallow to hold the femoral head a new shelf may be constructed.

**Abduction Paralysis.**—Legg's operation is valuable for this condition. It consists in transplanting the freed origin of the tensor fasciae latae backward so that it will act as an abductor.

**Deformities of the Upper Extremities.**—For the relief of paralysis of the deltoid muscle arthrodesis and tendon transplantations are useful but these procedures are of no value if there is no function in the hand and elbow.

In arthrodesis the humeral head is fused to the glenoid cavity. This operation is more successful when the tip of the acromion is fused to the humerus. The arm is placed in a spica in 70 degrees of abduction and the elbow just forward of the coronal plane. Brimford, Soutter, Lange, Mayer and others have used the upper trapezius to relieve the paralyzed deltoid muscle with more or less success.

Transplantation of the short head of the biceps and the long head of the triceps to the acromion when there is good or normal power gives excellent results. When these muscles are weak the trapezius operation may be combined with the biceps and triceps transplants.

**Elbow.**—*Flexor weakness* at this joint may be improved by transplanting the forearm muscles on the inner condyle 2 inches upward. This may be combined with a similar procedure on the lateral condyle (Steindler).

*Triceps paralysis* may be relieved by transplanting a normal brachioradialis posteriorly. This may be done without division of the muscle.

**Wrist and Fingers.**—The flexor carpi ulnaris may be transplanted to the extensor of the fingers to relieve extensor weakness.

*Paralysis of the opponens pollicis* is helped by Ney's operation and by Bunnell's operation or by a modified combination of the two (author's method) which is as follows: The extensor brevis pollicis is isolated as in the Ney operation and then the flexor sublimis digitorum of the ring finger above the wrist and divided. The first muscle is passed deep across the palm of the hand behind the finger flexors and the extensor brevis is sutured to the proximal portion of the finger flexor. The distal portion of the flexor is sutured to the flexor of the fifth finger.

*Wrist drop* may be corrected by fusion of the radius to the carpus or tenodesis of the wrist extensors.

**Spine.**—*Lateral curvature of the spine* is due to paralysis of the spinal abdominal or shoulder muscles. It may be due to a short leg or a contracted iliotibial

The function of the foot and ankle is twofold weight bearing and flexible locomotion. The normal weight bearing line is represented by a plumb line dropped from the middle of the patella. It falls through the middle of the astragalus and to a point between the bases of the first and second toes.

**Flatfoot**—Flatfoot may be either congenital or acquired. Heredity is undoubtedly an important factor. A type of flatfoot appears during adolescence in long slender rapidly growing feet especially in girls.



NORMAL INNER SIDE OF FOOT



Fig 267—Showing what occurs in case of a depressed longitudinal arch

Focal infection or any infectious disease can cause flatfoot by a toxic relaxation of the supporting structures. These infections may cause toxic arthritis and a rigid valgus deformity which is resistant to treatment. Obesity causes flatfoot in two ways: first by the strain of an excessive load when there is usually a disproportion between the weight to be carried and the size and power of the feet and lower part of the legs; second by the glandular imbalance which is found in conditions such as dystrophia adiposa.

**Metatarsalgia** means pain in the metatarsal region. Metatarsal troubles are more common in women because of the wearing of improper and incorrectly fitted shoes. Short or tight stockings are additional factors. Arthritis may cause metatarsalgia. Infections may be local or focal such as those due to infected teeth, tonsils, sinuses or abdominal or pelvic structures. Toxemia from an infection or from pregnancy is a causative factor. Static disturbances such as prolonged standing on hard floors and improper

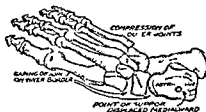
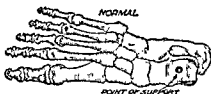


Fig 268—Bones of the foot (top view) in normal and flatfoot positions

genitalis in which there is genu valgum and talipes valgus due to relaxation of the supporting structures of the inner border of the knee and foot. Trauma may result in a pronated foot. Infantile paralysis is a frequent cause of valgus deformity.

The symptoms of flatfoot are fatigue, pain and stiffness. The gait is springless and ungraceful.

Physical examination reveals pronation of the midtarsal area with abduction of the forefoot. Heiberg's sign is an incurving of the achilles tendon (Fig 266 B).

sitting postures resting on the toes predispose to metatarsal disturbances. Traumas of various sorts are important viz strain or sprain as seen in the dancer's foot especially in toe dancing. Injury from falling objects or from being stepped on by another person or animal may cause metatarsalgia.

Treatment of metatarsalgia consists of local and general measures the latter being the removal of foci of infection and the correction of metabolic and hygienic disturbances. Local treatment consists of relief from inflammation or irritation proper shoes that



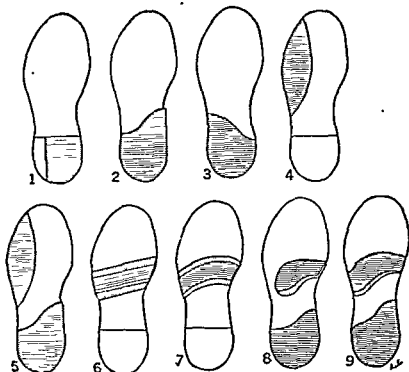


Fig 269.—Various types of shoe modifications or adjustments. Sole of right shoe shown 1, Elevation of inner border of heel 2 H O Thomas heel—inner border prolonged and elevated 3, Reversed Thomas heel 4 Elevated outer border of sole 5, Combined Thomas heel and elevated outer border of sole (flexible shank) 6 Robert Jones metatarsal bar (anterior heel) 7 Lewin rubber metatarsal crescent 8, Thomas heel plus Hauser metatarsal comma bar (flexible shank) 9, Thomas heel plus Lewin tilted, notched rubber metatarsal crescent (flexible shank) \*

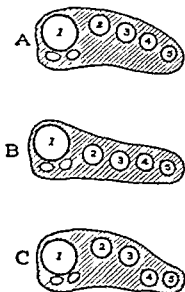


Fig 270.—A, Normal position of metatarsal heads and sesamoid bones, B depressed metatarsal arch, C, depression of fourth metatarsal head, with predisposition to callousity

are correctly fitted, metatarsal support and the physiologic restoration of the power of the supporting structures of the arch

McElvenny finds that Morton's toe is caused by a tumor involving the lateral branch of the medial plantar nerve. Careful palpation will usually reveal the tumor, which lies high in the web between the third and fourth toes. He advises excision of the tumor when the symptoms justify radical treatment.

**Pes cavus** is a hollow or contracted foot. The primary change is an exaggeration of the longitudinal arch. The secondary changes consist of limitation of dorsal flexion of the ankle joint and depression of the metatarsal arch with contractures of the plantar fascia and extensor tendons. Calluses and ulcers may appear.

**Bunion** is bursitis in the region of the big toe joint.

**Hallux valgus** is the outward deviation of the big toe with the formation of an overgrowth of bone (exostosis) at the big toe joint (Fig. 271). The chief causes are short or pointed shoes and injury. The most im-

\* Lewin The Foot and Ankle, Lea & Febiger, Publishers

portant prophylactic measure is the wearing of proper shoes. The McBride operation (Fig. 272) is useful

**Hallux varus** means the inward curving of the big toe.

**Metatarsus varus** means adduction of the forefoot.

**Hallux rigidus** means a rigid metatarsophalangeal joint. Both the flexed and the extended variety are due to injury or infection and may be relieved by the insertion of a thin strip of steel the entire length of

affords comfort, but occasionally removal of bone is necessary.

**Exostoses** of the first metatarsal usually occur on the lateral, medial and superior surfaces of the metatarsal head. The most frequently seen is the one occurring on the medial surface, which is so common in hallux valgus. In simple cases, removal of the exostoses gives complete relief. Exostoses of the fifth metatarsal usually occur on the lateral margin corresponding with those on the medial margin of the first metatarsal head

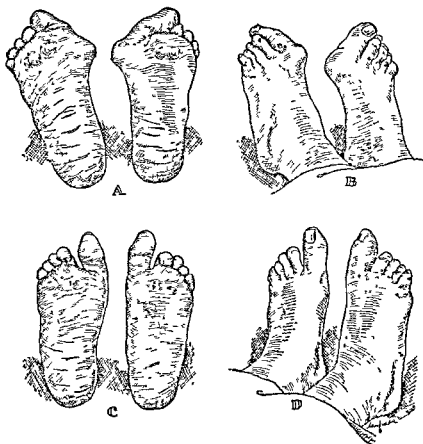


Fig. 271—Severe bunions and hallux valgus (Note the large plantar callosities in A)\*

the sole of the shoe so as to prevent movement at the big toe joint. The condition can be corrected by an arthroplastic operation.

**Sesamoiditis** is a painful condition involving the under surface of the big toe joint. This surface is subject to trauma in walking, in jumping from a height or in dancing. Often the roentgenogram will reveal a division of a sesamoid bone resembling fracture. Many of these are developmental peculiarities which are especially susceptible to injury. Usually relief from weight bearing

**Calcaneal or heel spurs** are due to various causes, such as (1) focal infections with the ordinary cocci, gonococci and spirochetes, (2) metabolic disturbances, especially of gastrointestinal and gallbladder origin (large numbers of cases are seen in which the metabolic factor either was most important or was an element in the exaggeration of other factors), (3) trauma due to injury and improper shoes, (4) static conditions due to flatfeet and (5) a short

\* Porter, J. L. Surg. Gynec. & Obst. 26

plantar fascia Painful heel may also be due to a wart perio-litis bursitis fascitis epiphysitis or an injury

*Treatment*—The causative factors—the residue of a gonococcus infection infected

pads are inserted in the shoes to relieve weight bearing on painful areas The heels of the shoes should be entirely removed and low rubber heels substituted

The diet is very important in cases of

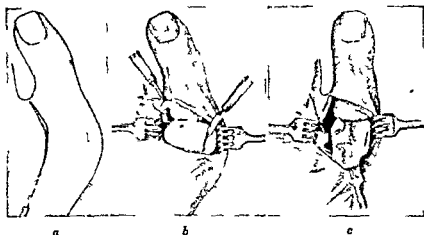


Fig 2—*a* Incision slightly curved laterally to the tendon of the extensor hallucis longus *b* The compound tendon of the transverse and oblique leads of the adductor hallucis and the flexor hallucis brevis are exposed and severed from their attachments The exostosis is exposed through the same incision *c* Transplanting the compound tendon to the head of the metatarsal The prominence of the metatarsal head has been removed\*

tonsils or teeth—should be treated if they can be found Any gastrointestinal disorder present should be corrected Weight bearing should be discontinued An anodyne lotion plus fomentations should be applied

metabolic disturbance As a rule in heavy patients meat, eggs fish starches and sweets should be reduced Diathermy or inductothermy may be beneficial for an accompanying arthritis



Fig 3.—Well-developed calcified spur causing no symptoms

After all pain and most of the sensitiveness have disappeared a plaster of paris cast should be applied Proper shoes are prescribed after from two to four weeks of wearing casts Shoes should be high laced and round toed with a straight last a medium width shank and a medium width ball

*Operative Treatment*—Operative trauma often stimulates osteogenesis especially if the infectious or causative agent is still present The size of the spur is not the determining factor The incision should be made along the inner border of the heel The re-

\* McBride F D J Bone & Joint Surg 10

removal of the spur is accomplished by means of a chisel and mallet. A plaster cast should be worn for about ten days.

Corns and calluses are due to pressure and irritation. Corns are of two varieties: 1. The hard corn which occurs on an external surface and is usually caused by an ill fitting shoe. This readily yields to good chiropody and proper shoes. If not too much irritated a corn may be amenable to home treatment by means of the ordinary corn plaster with a hole in the middle large enough to keep the corn free from further irritation. 2. The soft corn which occurs where two skin surfaces come together: e. g. where there is contact moisture and warmth. This type of corn is usually found between the fourth and fifth toes and is at times quite resistive to treatment. Dermatitis, taphytosis predisposes to soft corns because of the sogginess of the skin. In the treatment one must have separation of the skin surfaces, radiation of heat and evaporation of perspiration. Lamb's wool worn between the toes is of value. Flexible support for the anterior arch is usually helpful. Calluses are due to inconstant pressure or irritation. Constant pressure produces an ulcer or destruction of tissues. Inconstant pressure produces thickening of tissues or calluses. They are common under the ball of the foot especially back of the third and fourth toes. In this region they are due to depression of the heads of the metatarsal bones which help to make up the transverse arch. The patient feels as if he were walking on marbles or as if the bones were down on the ground and had no padding. This results in irritation of the periosteum covering the bones and occasionally in bursitis in this region. I. H. Ochsner has treated corns, calluses and warts with bichloroacetic acid.

Emery paper is effective in removing the painful factor.

Ingrown toe nail is due to the growth of the edge of the toe nail into the soft tissues. The most important site is the big toe nail where on either its medial or its lateral aspects the nail curves downward causing pressure and irritation of the soft tissue structures. This condition may continue until serious results are produced. The treatment includes the wearing of proper shoes and stockings, the picking of cotton under the nail and the scraping of the midportion of the nail thin in order to relieve pressure from the lateral margins. Most advanced cases require operation which includes removal of the lateral margin of the nail, the nail bed which forms the lateral margin and in some cases portions of the injured soft tissues.

Subungual warts are due to exostoses of the terminal phalanx causing irritation and hypertrophy of the epidermal tissues. Subungual exostoses are bony overgrowths which occur under the nail and frequently must be treated surgically.

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fore the location of choice for the scar is directly on the end of the stump

**Fascia**—To preserve the blood supply the fascia should be left attached to the skin flap when possible. To raise the skin and fascia separately damages the blood supply to both. Fascia is the normal envelope of the muscle and should be used to cover the muscle at the end of the stump. It also serves as a good covering for the cut end of bone as well as furnishing suitable tissue to which the cut ends of muscles may acquire a new insertion. When the muscle is properly covered with fascia adhesions cannot form between the muscle and the skin, thus a smooth stump end with movable skin is obtained.

**Muscle**—To allow for retraction muscles should be cut longer than bone. By grouping the severed muscles about the cut ends of bone new insertions may be required to the bone to each other and to the covering fascia. Careful attention to muscle grouping will prevent protrusion of bone beneath the skin and make a smooth well functioning stump.

**Nerves**—The most frequent cause of a tender stump is a sensitive neuroma which forms on the nerve end. The patient may complain much of feeling his toes or fingers and often a cramping drawing sensation causes great distress. For a long time he may complain of a phantom limb. Various plastic methods such as turning back and suturing nerve flaps, cutting a wedge from the nerve end and turning the nerve end back and suturing within the nerve sheath have been practiced with little success. Injection of the nerve above the point of section with 95 per cent alcohol as suggested by Huber and Lewis offers the best hope of avoiding the development of tender neuromas. Sectioning the nerves with a cautery, according to Hedri, will cause a degeneration of the nerve fibers upward for a distance of several centimeters. Kirk ligates the nerve high with plain catgut to control bleeding and injects the nerve trunk proximal to the ligation with 95 per cent alcohol. The nerve is then severed just distal to the ligature allowing it to retract 1 to 2 inches

carefully ligated with catgut. As little tissue about the vessels as possible should be included in the ligatures. Tissue strangulation by ligatures predisposes to sloughing and infection.

A tourniquet should be used in most cases to conserve time and facilitate neat workmanship. The exceptions are those cases in which the patient has an advanced arterial disease and a tight tourniquet might do further damage to the already seriously diseased vessels. Operating without a tourniquet in such cases enables the surgeon to judge whether the blood supply to the part is sufficient for good healing. When amputating at or near the shoulder or hip preliminary ligation of the large artery should be performed. Other vessels may be clamped as the incision proceeds making application of a tourniquet unnecessary.

Secondary hemorrhage is usually caused by infection and may occur several days following the primary operation. When an infected stump is being treated the nurses and assistants should be cautioned with regard to the possibility of hemorrhage and a tourniquet should be kept in readiness for immediate application as an emergency measure. It should be remembered that tourniquets applied for a longer period than an hour may permanently damage the tissues.

**Bone**—Length of bone is a prime consideration in making properly functioning stumps. Bone should not be needlessly sacrificed merely to make a neat operation when bone length is needed for leverage and strength in the wearing of an artificial limb. The cut end of bone should not come in contact with the overlying skin flap if that can be avoided. An otherwise excellent stump may be ruined by necrosis of the skin flap which has not been sufficiently protected from bone pressure by interposing fascia or muscle tissue.

The treatment of the periosteum is important. Most surgeons now agree that the apertosteal method (Hirsch Bunge) is the most satisfactory. The periosteum is completely removed for a distance of about 0.5 cm ( $\frac{1}{4}$  inch) above the saw line. Before the bone is severed this should be accomplished by circling the bone with a knife and scraping the periosteum downward with a

sharp curet By this procedure the saw does not pass through and shred the periosteum In the presence of infection it is considered unwise to remove any periosteum above the saw line because of damage to the blood supply which predisposes to bone necrosis The marrow is not disturbed Its removal does not make healing any smoother and the blood supply in the medulla may aid in healing As healing advances the open medullary cavity at the end is sealed with new bone

The various musculoperiosteal and periosteal methods of treating the severed ends of bones are of doubtful value The periosteum is very sensitive tissue and when it covers the bone end a tender stump or spur formation will result

Bleeding from the cut end of the bone can usually be controlled by crushing the vessel against the bone with a blunt instrument or by applying hot moist compresses bits of fresh muscle tissue or bone wax

All rough portions of bone should be removed with saw rasp and rongeur Sharp or rough edges may by slight pressure cause necrosis of the overlying fascia or skin

*Sutures and Ligatures*—Small vessels may be ligated with fine plain or chromic catgut No 0 chromic catgut is suitable for the ligation of large arteries and for sutures in the fascia Non absorbable sutures of silk or silkworm gut are used in the skin Interrupted or end mattress sutures make a smooth closure and prevent turning in of the skin edges The skin stitches may be removed from clean wounds on the seventh postoperative day

*Use of Sulfonamides*—Implantation of one of the sulfonamides is indicated in amputation wounds following trauma when infection exists in the extremity Oral or parenteral administration of a sulfonamide may also be of value to prevent the spread of an infection from an infected amputation wound

*Drainage*—With proper preparation of the skin careful technic and thorough hemostasis it is doubtful if drainage is necessary in any clean amputation A stump that is infected should always be drained with one or more small rubber tubes or rubber tissue drains Drains placed between

stitches usually cause the least puckering of scar and delay in healing

*Dressings*—For clean stumps a light gauze dressing applied snugly is sufficient Care should be taken not to bandage the extremity above the stump so tightly that the circulation is impaired and edema increased After twenty four hours there is usually sufficient swelling to make the dressing uncomfortably tight and it should then be changed Infected stumps require frequent changes of dressings

Splinting especially at the knee is desirable in most cases to prevent contracture A thin flexible splint such as vuca board well padded with cotton is efficient

*The Amputation Stump*—Following operation the amputation stump should receive the same watchful care as any other postoperative wound The first dressing should usually be made after twenty four hours chiefly to promote the patient's comfort by relieving pressure due to edema If a drain has been used it may be removed in forty eight hours if no evidence of infection exists Early signs of infection as evidenced by a rise in temperature increased pain edema redness of skin purulent discharge and leukocytosis are of great importance At the first evidence of infection a sufficient number of stitches should be removed to give adequate drainage Tension must be relieved to avoid sloughing Warm moist boric acid compresses and drainage and increase the blood supply It must be remembered that there may be some reaction with fever and swelling of a stump without infection Absorption of blood and damaged tissue will cause a rise in temperature as will also a definite hematoma

The average clean stump will heal in from ten to fourteen days and will be ready for fitting with a temporary artificial appliance in five or six weeks During healing especially if prolonged by infection the stump should be placed in a position to prevent deformity At the knee a flexed position is often most comfortable and the patient tends to maintain flexion until contractures develop unless prevented by splinting or frequent exercises and change of position Flexion deformity at the hip commonly accompanies prolonged healing This is avoided by insisting on proper position

ful attention should be given to the removal of all dead bone and sinus tracts.

# AMPUTATIONS OF THE UPPER EXTREMITY

and.—The indications for amputation of fingers or hands are usually trauma, in-

jury does not differ from amputation through the bone in any essential detail. It is not necessary to remove the articular cartilage.

All the fingers should be amputated at the metacarpophalangeal joints when damaged beyond any possibility of repair. Any part or all of the metacarpal portion of the hand

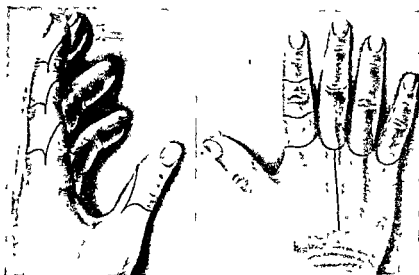


Fig 274—Skin incisions for finger and metacarpal amputations \*

fection or deformity. The most careful judgment is necessary to avoid removal of too much of the hand. In many cases tissue that at first examination appears to be injured beyond repair later heals and functions normally. It should, therefore, be the rule that all parts possible be saved. Scarred, stiff, tender or deformed fingers which have lost their function should be amputated so as to be out of the way. The thumb deserves special consideration, since without this digit the function of grasping is largely lost. A single finger or even a portion of a single finger and a functioning thumb are superior to any artificial appliance.

Long palmar and short dorsal skin flaps are preferable (Fig 274). The palmar tissues are better adapted to pressure than the dorsal and will make firmer and less tender stumps. Flaps should be made of sufficient

may be removed. Long palmar and short dorsal flaps give the best results. Any part

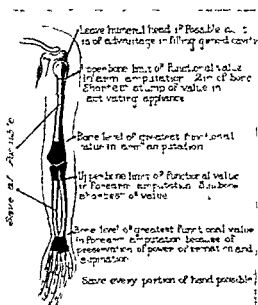


Fig 275—Locations of choice for amputations of the upper extremity

\* Orr: Modern Methods of Amputation C. V. Mosby Co., Publisher

exercise At the shoulder the stump is maintained in abduction until the lessening of pain and tenderness permits exercise Early fitting is recommended to restore function and avoid crippling habits Elastic bandages are useful to reduce the edema in stumps and to promote shrinkage preliminary to limb fitting Artificial limb fitters usually apply a leather shrinker for a few weeks preliminary to fitting As soon as the wound is healed full range of motion of the nearest joint is important To this end exercises are encouraged and massage is indicated Massage also aids in reducing edema and tends to toughen the tissues Frequent bathing with alcohol is also of value in toughening the skin

*Tender Stumps*—The principal causes of tender stumps are infection ulceration disturbed circulation neuromas sensitive scars nerve ends involved in scar tissue bone spurs periostitis osteomyelitis and neuritis

Much difficulty may be experienced with furunculosis on the limb at the site of weight bearing This is especially noticeable at pressure points below the knee and at the hip When such infection exists it is wise to discontinue the wearing of an artificial limb until it subsides The use of hot moist packs is recommended to allay the inflammation Points of suppuration should be drained by small puncture wounds to minimize scarring as much as possible Lack of proper hygiene of the stump is often responsible for such infection Daily bathing followed by application of alcohol is useful in preventing skin infections Eczema near the stump end in folds of the skin and about scars is best treated by a plastic operation if proper hygiene fails An acute infection about the end of the stump is easily detected and should receive the same type of treatment as infection elsewhere

Persistent ulcers in the scar at the stump end are relatively common The causes of chronic ulcerations are usually infection direct trauma and disturbed circulation Just how much trophic disturbances are responsible for the development of ulcers on the stump is problematic If the cause can be determined it should of course be removed In some cases the removal of underlying bone infection the proper adjustment of a limb or a plastic operation for a poorly

placed scar may give relief In circulatory disease reamputation may be advisable Perirteral sympathectomy is reserved for carefully selected cases in which there is some hope of success During treatment the use of the artificial limb should of course be interdicted

Stumps with redundant soft tissues are often edematous and sensitive Ends of stumps may be blue and cold especially leg stumps that are made too long An ill fitting artificial limb may disturb the circulation and produce pain

Neuromas which form on the cut ends of nerves are often sensitive if located where they receive pressure or irritation They may be removed if necessary and the nerve above injected with 90 per cent alcohol Occasionally a stump is found in which neuralgic pains are disturbing This condition may also be corrected by shortening the nerves that are subject to irritation The removal of focal infection in rare cases gives some relief

Sensitive scars should be removed by a proper plastic operation and new scars placed in a position least exposed to trauma

Periostitis and osteomyelitis should receive the treatment accorded elsewhere in the body Sequestra should be located and removed as soon as separated from living bone At times a change in the fitting of an artificial limb will relieve periosteal irritation

Bone spurs are the result of a shredded periosteum or infection and should be removed if they produce symptoms The mere presence of a bone spur is not an indication for its removal

Contractures constitute a deformity which is likely to occur if the proper treatment is not carried out during the healing period The best treatment is always prevention The surgeon will be much aided by explaining to the patient how and why contractures follow amputations and urge his cooperation in maintaining the proper position of the stump and by starting early exercise of the nearest joint After contractures have formed massage with active and passive motion is of value In the more severe cases traction with weights may be used Operation may be resorted to in some cases but is often unsuccessful because the contrac-



ture frequently involves all the tissues in and about the joint including the joint capsule

Deformities due to contractures are of great importance from the standpoint of artificial limb fitting. It is obvious that any contracture at the hip, knee or ankle will render the part difficult to fit with a weight bearing prosthesis. The shorter the stump the greater the likelihood of contracture. Any contracture that has existed for a considerable period of time presents a serious problem and may necessitate reamputation. This is especially true of such deformities at the ankle or knee.

**Scars**—The proper placing of scars in locations to avoid friction is an important part of the operative technique. When a technique of choice is not practicable or when infection occurs, poorly located or adherent scars may be troublesome. When a scar is adherent to bone it may ulcerate or cause pain by direct pressure or as a result of traction due to motion of the stump in an artificial limb socket. Such a scar should be removed and an effort made to secure a covering of the bone ends with fascia and movable skin. If the bone is of sufficient length, reamputation may be performed. A scar that does not interfere with function should usually be left undisturbed. Bursae may form beneath scars over bony prominences, rendering them more movable and less liable to irritation. Scars that are directly adherent to muscle tend to pucker and infold until chafing becomes disagreeable or painful. Such scars may be successfully excised and the fascia interposed between muscle and skin.

A conical stump results from a retraction of muscle which leaves the bone protruding beneath the skin or fixed to a scar. An improperly treated guillotine amputation will frequently result in a conical stump. As a rule, such a stump is prone to be tender and to require reamputation.

**Jerking stumps** an annoying complication of amputation may be more or less persistent. The jerking usually occurs when the patient is thinking of his condition or when the stump is being examined. The basis of such a disability is usually nervous and difficult to control. In some cases the removal of tender nerve endings may effect a cure.

Any treatment should be accompanied by assuring the patient that the condition is curable and will be cured. Such patients can usually be fitted satisfactorily with artificial limbs.

**Lengthening Stumps**—An arm stump may be lengthened from  $\frac{1}{2}$  to 1 inch by severing the insertion of the pectoralis major muscle near the humerus with temporary fixation of the stump in abduction. When the resistance of this muscular attachment is removed, the anterior axillary fold may be pushed upward. An operation has been suggested by Openshaw to lengthen a short forearm stump by removing much of the bulky muscle from the condyles of the humerus. Plastic operations on the hand to lengthen the thumb have been used with some success. By separating the first and second metacarpals, an increased gripping power of the stub of a thumb may be obtained.

**Skin Grafting**—As a rule, the skin grafting of ulcerated stumps is unsatisfactory if an artificial limb is to be worn. Free grafts and the accompanying scars do not tolerate weight or friction well and are apt to ulcerate. This does not apply to pedicle flaps of whole thickness skin or skin and fascia. Such flaps, properly placed with due respect to the laws of plastic surgery, may result in useful stumps.

**Reamputation** following the guillotine operation is indicated in a high percentage of cases. Other indications are protruding bone, infection, tender stumps as a result of bone spurs, redundant soft parts to reshape or shorten an unsuitable stump and the removal of troublesome scars.

If a plastic operation is to be done to reshape a stump or if an ulcer is to be removed and the stump shortened, the operation should be postponed until proper treatment has reduced the infection to a minimum and until a brawny edema has disappeared from the skin and subcutaneous tissues. An ulcer on a stump end is not a contraindication to reamputation or a plastic operation provided the surrounding infection is eradicated. It is wise to scar the surface of the ulcer with pure carbolic acid to avoid wound soiling before making a nearby incision.

**Open or Guillotine Amputation**—The

term guillotine as applied to amputations was revived during the first World War and the method was used extensively at the front. While not an ideal term it is probably in the literature to stay. As a general term it means any amputation in which the severed parts are left entirely open so as to aid drainage.

The open amputation in the strictest sense is always a method of second choice. In many instances it is undoubtedly life saving as well as being of great value in conserving the length of the bone. When possible it is made at a location which will later permit a higher final amputation to form a sound well functioning stump. Its chief objections are the necessity of another operation and the great prolongation of convalescence.

In the first World War this method was chiefly used to avoid or treat the much dreaded gas bacillus infection. It is now being used in the second World War in the zone of operations to prevent serious infections. It has a definite place in the treatment of the injured in civil life. When an extremity is traumatized this operation may be a life saving measure as it minimizes the operative treatment necessary during severe shock and conserves the length of the limb. Too often a closed amputation is performed for a mangled arm or leg at a high point where subsequent infection will ruin the stump when an open stump would have been the method of choice. The surgeon who undertakes traumatic surgery should be familiar with the modern sites of election for amputation from the standpoint of artificial limb wearing and should select the open method of amputation when it is indicated to make stumps of proper length. A patient with a foot crushed and lacerated beyond repair in a state of shock or with beginning gangrene from delayed treatment is a candidate for a guillotine amputation at or near the ankle to enable the surgeon later to do a clean operation through the site of choice in the middle third of the leg.

Acute pyogenic or gas forming infections are often an indication for the guillotine method of amputation. Infection of bones, joints and soft tissues when damaged beyond functional repair or when endangering life usually calls for the open operation. Am-

putation by the closed technique above an infected part is always a questionable procedure unless the infection has subsided and become local.

The technique of the open amputation depends somewhat on the location. It may be hurriedly done by direct circular section of all tissues by making skin and fascia flaps or by sectioning the tissues obliquely. The first method is rarely indicated. Skin and fascia flaps of moderate length should usually be made and the muscle cut from 5 to 7 cm (2 to 3 inches) longer than the bone to allow for retraction. The skin and fascia may be packed open with gauze dressing or even temporarily sutured back to the skin above if severe infection is feared. When it is necessary to do the open amputation at a site most suitable for a final stump greater care should be used in operating with the hope that healing may take place with or without secondary closure and reamputation may be avoided. In such a case the nerves should be injected with 95 per cent alcohol and divided high, the muscle near the bone cut shorter than the superficial muscle and the skin and fascia carefully preserved together. It is unwise in the presence of infection or when infection is anticipated to remove periosteum above the line of bone section or to curet the marrow because of the danger of damaging the blood supply of the bone. Extension by adhesive straps with weight and pulley or with a Thomas splint may be used with success.

The postoperative treatment of the open amputation wound should receive close attention. Frequent inspection should be made to avoid pocketing of pus and ascending infection. The Carrel-Dakin method of treatment is satisfactory until the infection is localized and under control. Hot moist packs saturated with boric acid solution are of much value. Local application of one of the sulfonamide drugs is indicated in such fresh wounds to prevent the development of infection. In selected cases secondary closure may be considered if the wound is clean and the site of amputation is satisfactory. A sequestrum may form in an infected guillotine stump. Its presence is detected either by direct instrument examination or by x-ray plates. If the stump is to be closed by plastic operation without reamputation

careful attention should be given to the removal of all dead bone and sinus tracts.

### AMPUTATIONS OF THE UPPER EXTREMITY

**Hand.**—The indications for amputation of fingers or hands are usually trauma, in-

does not differ from amputation through the bone in any essential detail. It is not necessary to remove the articular cartilage.

All the fingers should be amputated at the metacarpophalangeal joints when damaged beyond any possibility of repair. Any part or all of the metacarpal portion of the hand

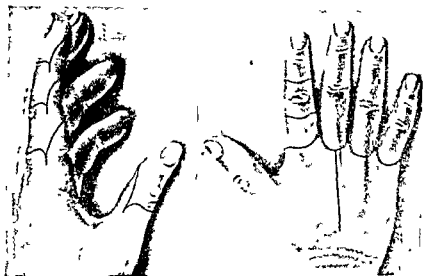


Fig. 274.—Skin incisions for finger and metacarpal amputations.\*

fection or deformity. The most careful judgment is necessary to avoid removal of too much of the hand. In many cases tissue that at first examination appears to be injured beyond repair later heals and functions normally. It should, therefore, be the rule that all parts possible be saved. Scarred, stiff, tender or deformed fingers which have lost their function should be amputated so as to be out of the way. The thumb deserves special consideration, since without this digit the function of grasping is largely lost. A single finger or even a portion of a single finger and a functioning thumb are superior to any artificial appliance.

Long palmar and short dorsal skin flaps are preferable (Fig. 274). The palmar tissues are better adapted to pressure than the dorsal and will make firmer and less tender stumps. Flaps should be made of sufficient length to avoid tension when sutured. Length of bone should not always be sacrificed to obtain perfect skin flaps. Irregular flaps may at times produce good functional results.

The technic of disarticulation at an interphalangeal or metacarpophalangeal joint

may be removed. Long palmar and short dorsal flaps give the best results. Any part

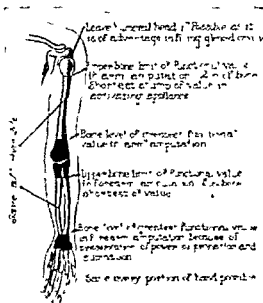


Fig. 275.—Locations of choice for amputations of the upper extremity.

\* Orr, *Modern Methods of Amputation*. C. V. Mosby Co., Publisher.

having the slightest likelihood of future function should not be sacrificed to obtain an ideal closure even though a plastic operation may be required later. The bones are cut smoothly, and the periosteum is removed from the severed ends. Tendons and muscles should be sutured together over the

paratus fitted to a wrist stump will project beyond the length of a normal hand, producing an awkward appearance. It is often desirable to amputate through the wrist and then reamputate later, when the general condition of the patient and the local condition of the part have improved. If a seri-

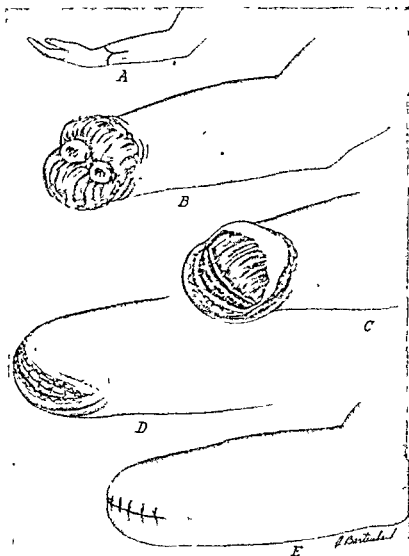


Fig. 276—Amputation through the forearm. A, Anterior and posterior skin and fascia flaps of equal length. B, Muscle is reflected showing bone ends denuded of periosteum. C, Muscles closed over the ends of the bones with mattress sutures. D, Deep fascia is closed over the muscles with interrupted sutures. E, Skin closed with interrupted sutures of silk or other non-absorbable suture material.\*

ends of the bones with chromic catgut. Nerves should be divided high and all bleeding vessels ligated with plain catgut. Drainage is not necessary except when infection is present or anticipated.

**Forearm.**—An amputation through the wrist joint results in a poor stump as far as artificial limb fitting is concerned. Any ap-

paratus fitted to a wrist stump will project beyond the length of a normal hand, producing an awkward appearance. It is often desirable to amputate through the wrist and then reamputate later, when the general condition of the patient and the local condition of the part have improved. If a seri-

\* Orr, *Operations of General Surgery*. W. B. Saunders Co., Publishers.

fitting an artificial prosthesis the site of choice for amputation through the forearm is at the junction of the lower and middle thirds (Fig 275) Good stumps are often produced by amputation just above the wrist but in many cases such a stump becomes sensitive because of a disturbance of the blood supply A forearm stump shorter than 2 inches cannot be successfully fitted with an artificial limb This measurement is taken from the biceps to the end of the stump with the arm flexed at a right angle As the biceps is inserted into the radius below the head it tends to push the artificial limb bucket off the stump when the elbow is flexed Disarticulation should not be performed through the elbow except as a temporary measure Such an amputation produces a bulbous stump which must be fitted with a laced socket above and a wide unsightly flange at the elbow

**Arm and Shoulder**—It has been mentioned in the previous section that it is usually unwise to disarticulate at the elbow joint. The most satisfactory arm amputation is made just above the condyles. An arm stump shorter than 3 inches measuring from the axillary fold is unsatisfactory for artificial limb fitting. Disarticulation at the shoulder is rarely indicated since it is wiser to leave the head of the humerus in its socket so as to prevent a flattening of the shoulder which is disfiguring and often may be detected through the patient's clothes. As in the forearm amputation anterior and posterior flaps of equal length are preferable. The pressure from an artificial limb is largely lateral therefore a scar placed on the end of the stump would be less likely to be irritated by a limb socket. Amputations through the surgical neck or at the shoulder require different types of flaps to avoid placing the scar near the point of the shoulder where it would be exposed to pressure.

**Interscapulothoracic Amputation**—Fortunately this amputation is rarely indicated. It is rather elaborate and usually associated with considerable shock. Certain tumors of the upper end of the humerus and scapula or extensive trauma to this region may make the amputation necessary. It is not advisable to perform such an amputation in the presence of acute infection.

## AMPUTATIONS OF THE LOWER EXTREMITY

**Foot and Ankle**—Since the two chief functions of the lower extremities are locomotion and weight bearing it is important to consider amputations from the standpoint of future artificial limb wearing (Fig 277). Exceptional cases of course require special consideration—old age and other disabilities which prevent activity. Amputation of the toes does not as a rule cause great disability. Loss of a great toe is more likely to disturb the gait than the loss of any other toe. With the exception of the great toe it is wise not to leave a single toe on a foot when

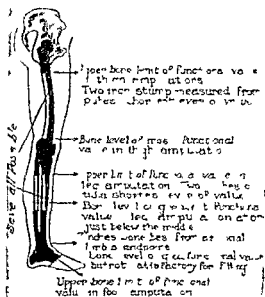


Fig 27—Locations of choice for amputation of the lower extremity

the other toes are completely amputated. A single toe is likely to be painful and deformed and to cause greater disability than no toes. Amputation of the second toe is somewhat objectionable in that hallux valgus may be produced by lack of lateral support of the great toe.

Any amputation through the metatarsals will produce a good functioning stump provided there is sound healing and the scar is properly placed so as to prevent painful pressure points. The I-I frame operation which is a tarsometatarsal disarticulation will produce a useful stump provided the flexor and extensor tendons are properly fixed to the stump end so that they will retain their function. A loss of muscle bal-

ance is likely to result in contractures which will destroy the usefulness of the stump

Any amputation between the Lisfranc and the Syme is of doubtful value. The Chopart and Pirogoff (Fig 278) which have been the other classic amputations in this region have serious faults which often necessitate reamputation through the leg. The Chopart amputation is a mediotarsal disarticulation and frequently results in a poor stump because of muscle imbalance resulting in contracture of the muscles of the calf and the tilting downward of the stump end. The latter causes faulty weight

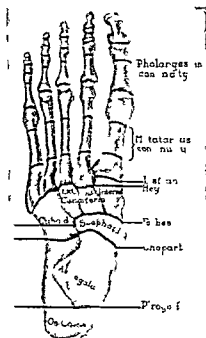


Fig 278—Skeletal lines of incision in several of the well known foot amputations (Redrawn from Orr)

bearing and difficult fitting. The Pirogoff is an osteoplastic amputation in which the posterior portion of the os calcis is retained in the heel pad and turned forward to unite with the tibia and fibula after removal of the malleoli. The first objection to this technique is the difficulty in obtaining sound healing between the posterior part of the os calcis and the lower end of the tibia. The second serious objection is the subsequent difficulty of fitting an artificial limb. Subastraloid disarticulations have much the same objectionable features as the Pirogoff. Practically the only argument in favor of

the Chopart, Pirogoff and other amputations through the tarsal bones is that they produce an end bearing stump which enables the patient to walk without an artificial limb. It is generally considered by surgeons of experience that the objectionable features of these amputations far outweigh the beneficial features. It is much better to discard all amputations between the Lisfranc and the Syme unless one of them is performed as a trial measure with the full understanding that reamputation may be necessary later.

The Syme amputation is made just above the malleoli, the heel pad being used to cover the bone ends. This amputation gives the patient an end bearing stump and enables him to go about his room without a crutch or artificial limb. There is division of opinion among surgeons in regard to the value of this amputation. Some give it high praise and others advise against it, stating that subsequent amputation through the leg is necessary in a high percentage of cases. Undoubtedly a properly made Syme stump has few objections and can be recommended. The fitting of a Syme stump with an artificial limb is difficult and results in an unsightly ankle in most cases.

**Leg**—From the standpoint of artificial limb fitting the best amputation above the ankle is through the middle third of the leg 7 inches (18 cm) below the knee (Fig 279). Amputation through the lower third of the leg is unsatisfactory because practically always the stump becomes atrophic, tender and cyanotic. Long leg stumps are also difficult to fit. A leg stump shorter than 2 inches (5 cm) below the biceps tendon with the knee flexed at right angles is unsatisfactory for fitting purposes. Removal of the entire fibula is indicated when a stump is shorter than 3 inches (8 cm). The old term site of election meant that an amputation should be performed about 4 inches below the knee so that a peg leg could be used with the knee for weight bearing in a kneeling position.

**Thigh**—It is well known that amputations through the thigh or at the hip are accompanied by more shock than those below the knee and this fact should be taken into consideration when judging a patient's operability. General or spinal anesthesia is used.

Disarticulation of the knee joint is rarely

advisable because of the resulting bulbous stump produced by the femoral condyles. Such stumps are difficult to fit with artificial limbs and are unsightly. They are inferior to those stumps produced by the Griggs Stokes or supracondylar amputations. The osteo-

myd and the tendon of the quadriceps extensor muscle sutured over the bone end as a long anterior flap. Callender has also described a tendoplasty amputation at the knee designed for weight bearing. Long anterior and posterior skin and fascia flaps are

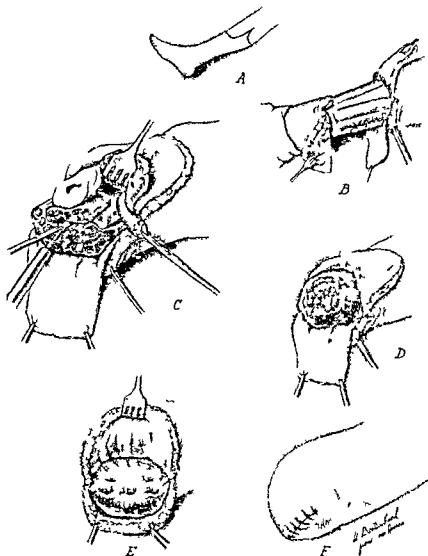


Fig. 9.—Technique of leg amputation. *A* Anterior skin flap reflected. *B* Anterior skin flap reflected. *C* Crest of tibia has been removed and patella has been cut and sutured from the bone. *D* Muscles grouped about the bone. *E* Posterior fascial flap sutured over muscles at bone ends. *F* Skin flaps closed.\*

plastic Griggs Stokes amputation at the knee when properly performed makes a good end bearing stump. The tendoplasty supracondylar amputation as described by Kirk with proper technique and after training may produce an end bearing stump not inferior to the Griggs Stokes. The femur is di-

vided and the hamstrings are severed at their insertions the femur is divided just proximal to the adductor tubercle and the patella is removed from the rectus femoris tendon leaving a flange for the end of the

\* Orr, *Operations of Cerebral Surgery*. W. B. Saunders Co., Philadelphia.

femur Callender states that his technic reduces mortality by lessening shock by shortening the period of bed rest by reducing the incidence of infection due to long flaps with little tension and few sutures by adequate drainage of serum from the wound and by decreasing the incidence of reamputation

An *interthoracoabdominal amputation* is a very formidable operation and is rarely indicated. In well selected cases it may be performed to remove extensive neoplasms of the ilium. The entire innominate bone or a portion of it may be removed with the lower extremity. The operative mortality rate is over 50 per cent.

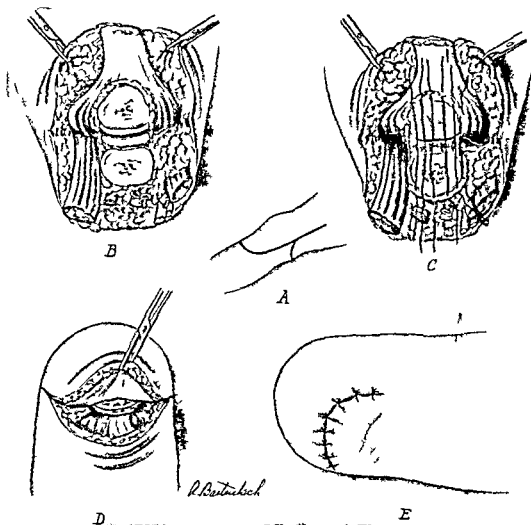


Fig 280—Steps in the Grill-Stokes amputation technique. A Lines of the skin incisions B Appearance after femur is sectioned and the articular portion of the patella is removed. The skeleton also shows the divided quadriceps extensor tendon and the ends of sectioned muscles, nerves and vessels C Sutures placed to fix patella to cut end of femur D Hamstring muscles and tendons sutured to patellar tendon E Appearance of stump after closure of skin flaps.

Other thigh stumps should be made as long as possible in order to give strength and leverage for the wearing of an artificial limb. A stump shorter than  $3\frac{1}{2}$  inches (9 cm) measured from the perineum has little more value for fitting purposes than a hip joint disarticulation.

#### KINEPLASTIC AMPUTATIONS

Any plastic operation on an amputation stump which enables it to transmit voluntary movement to an artificial limb or appliance is termed a kineplastic amputation.

\*Orr: Operations of General Surgery. W. B. Saunders Co., Publishers.



The points of attachment for prostheses on the amputation stumps are termed *motors* or *plastic motors*.

This highly specialized phase of amputation was first introduced to surgery by *Guilian Vanghetti* an Italian surgeon, in the year 1896. While his work was experimental, it was a stimulus to others to make practical application of his suggestions.

Outstanding contributions to this subject have been made by *Sauerbruch* in Germany, *G. Bosch Aranz* in South America and *Putti*, *Pellegrini* and others in Italy. Any one interested in the subject should read the works of these authors.

At present the practical value of *kineplastic amputations* is somewhat difficult to estimate. Unless the surgeon is especially interested in this type of surgery, such methods should not be attempted. To make efficient kinematic stumps requires not only a knowledge of the necessary surgical technique, but an interest and knowledge in the manufacture and fitting of proper artificial appliances. This field of work has not been sufficiently developed for limb makers to interest themselves in fitting suitable prostheses. The results of present methods of fitting amputations of the lower extremity are so satisfactory that kinematic stumps offer little or no advantage. The greatest field for development will undoubtedly be in the arm. Any workable method which increases the ability to perform the finer movements of the fingers should be encouraged.

Plastic motors are commonly classified as *club* or *clava*, *loop* or *ansa*, *muscle tunnel*, *tendon tunnel* and *pseudarthrosis*. They are also frequently designated as *unimotor*, *bi-motor* and *plurimotor*, depending on the number of motors constructed. The *club motor* is a knob like mass of muscle or tendon covered with skin to which a loop or ring of a prosthesis may be attached. A *loop motor* is formed by joining opposing tendons and muscles and covering them with skin. The *muscle tunnel motor* is made by tunneling through the muscle tissue and lining the tunnel with a pedunculated flap of skin. The *tendon tunnel* is constructed in much the same manner as the muscle motor. The *pseudarthrosis motor* is constructed by

severing the bone near the stump end and leaving a bone segment in the distal muscle tissue, which is rendered mobile by the lack of union of the bone.

Any plastic motor to be efficient must have muscle power, a healthy skin covering a range of motion sufficient to move the artificial appliance, sufficient length and strength and a good solid surface for counterpressure. The range of motion of a motor should be at least 1 inch (2.5 cm) or, better, from 1½ to 2 inches (from 3 to 5 cm).

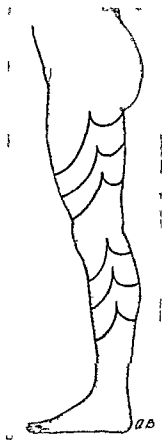


Fig 951—Lines of skin fascia incisions for amputations through the lower extremity.\*

It is possible to perform a primary kineplastic operation. If it is to be done as a secondary operation, all possible tissue should be conserved at the primary amputation.

THOMAS G. ORR

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## PROSTHESIS

Prosthesis (prothesis) is defined as the replacement of an absent part by an artificial one. While teeth and bony and soft part defects are included the term is most frequently applied to the fitting of artificial limbs.

An amputation stump should be ready for fitting with a prosthesis six weeks after a closed amputation or the repair of a gunshot stump unless healing has been delayed. When the suture line is healed physiotherapy is begun in order to mobilize the joints, strengthen muscles, reduce edema and toughen the skin. Daily massage and active passive and resistant exercises are prescribed. The skin is bathed liberally with alcohol and a tightly applied Ace bandage is continually worn. Free motion in all joints of a stump leg or arm and muscle power equal to that of the normal extremity are essential for the proper activation of a prosthesis. Ten days after operation the patient begins gently at first to pound the stump end with his open hand; next is practiced direct weight bearing on a soft pillow during the fourth postoperative week. This is essential in end bearing stumps and is valuable in making the non-weight bearing stump painless.

Early fitting with a temporary prosthesis produces a physiologic shrinkage of the stump and develops weight bearing points and the muscles necessary for propulsion. Pressure and use hasten the absorption of fat and edema and encourage the atrophy of muscle which has no further function. The end result is quite the opposite to what occurs if the stump is allowed to shrink by the atrophy of disuse aided by various types

of 'shrinkers'. Under the latter circumstances edema increases as a result of dependence; fat is deposited in the subcutaneous layers; joint deformities tend to occur; muscle power lessens and the stump becomes painful and useless. Changes in the soft parts of a stump of the lower extremity known as shrinkage continue for a period of approximately six months. The stump then assumes its more or less stationary form and is ready for a permanent prosthesis.

The fitting of a stump of the upper extremity with a temporary prosthesis is not as essential as in the lower extremity and many of the stumps may be fitted at once with a permanent type of prosthesis.

In the lower extremity there are two types of prosthesis: end bearing in which the weight of the body is borne on the stump end and cone bearing in which the weight is borne above the stump end and the stump itself acts as a lever activating the prosthesis.

The Syme and Pirogoff stumps in the leg, the Gritti Stokes and the supracondylar tendoplasty stumps in the thigh are end bearing stumps and should be so fitted. All other stumps except certain other amputations through the lower third of the thigh are fitted by the second method. In the leg, the weight is borne by the shelving inner tuberosity of the tibia, the fibula below its head and by the cone bearing action of the soft parts of the stump itself against its rigid bucket. Weight must be relieved over the tender head of the fibula, the peroneal nerve below it and over the tubercle and the crest of the tibia. In the thigh the weight is borne on the tuberosity of the ischium where the shelving upper edge of the thigh bucket is molded to receive it, supplemented by the thrust of the stump itself into the well fitting bucket.

The bucket or socket, that part of a prosthesis which is built to receive the stump, should always be of rigid construction in the lower extremity. The best type of prosthesis for the lower extremity has knee, ankle and toe motion. The stump is covered and protected by at least one knitted white woolen stump sock. These socks are changed daily and kept meticulously clean to prevent skin infection. The prosthesis is secured in place by means of straps over the shoulders or is

attached by straps to a belt. The short or fat thigh stumps are further secured in position by the use of a pelvic band of metal and leather which is attached to the prosthesis with a jointed metal bar.

### TYPES OF PROSTHESIS

**Temporary Appliances**—1 *Plaster of Paris*—This is constructed by the surgeon at the hospital or office and consists of a bucket which fits the individual stump. It is made of plaster of paris and supported on a peg crutch or metal set up. This type is always available and inexpensive and meets the necessary requirements.

2 *Molded Leather*—This type is factory made and consists of a molded semirigid leather bucket with leings which allows adjustments as shrinkage occurs. It is supported by metal side bars with joint motion in the knee, ankle and foot.

3 *Vulcanized Fiber*—This type is factory made, is obtainable in any quantity desired and is easily taken apart and rebuilt to fit the individual stump by any competent orthopedic mechanic. It is durable and cheap and simulates the permanent type in its mechanics. The thigh bucket and skin piece are made of fiber, the knee block and foot are of wood. Adjustments are easily made as stump shrinkage occurs. The below knee bucket is made locally of leather molded over a plaster mold of the stump which supplements the below knee fiber set up. This type of temporary prosthesis was adopted by the U. S. Army during the first World War.

**Permanent Appliances**—The permanent types of prosthesis are made of English willow wood covered with rawhide, vulcanized fiber and duraluminum. The rigid type of bucket is preferred. It is made of the following willow cut from a solid block to fit the stump, leather accurately molded and sewed to fit a model fiber shaped and molded by heat and pressure, and duraluminum. Willow is lighter in weight than leather, it may split or crack, but it is ideal if properly fashioned. Leather is easier to mold but becomes

soiled with perspiration. The duraluminum leg may have a bucket of the same material but willow or leather is usually employed. In fitting certain stumps both willow and leather are used. Manufacturers differ regarding the construction and mechanical control of artificial feet, ankle and knee joints. The type which is made of the best material has the best design and is lightest in weight should be chosen.

The essentials of a satisfactory prosthesis are:

1 A properly fitted bucket.

2 An alignment of the prosthesis joints which must be at proper angles with the weight bearing line and must have proper lateral alignment.

3 Lightness in weight combined with durability.

The thigh prosthesis should be  $\frac{1}{2}$  inch shorter than the normal leg to allow the amputee to swing through. The below knee prosthesis is made equal in length. It is important that the below knee bucket fit the stump snugly and extend beyond its length. Special types of prosthesis are required for the Pirogoff, Syme, Chopart and hip joint amputations. In the upper extremity the buckets are made of leather, fiber or willow. The so called utility arm with a split hook of the Dorrance type is probably the best working tool. There are several types of mechanical hands on the market; they are more expensive than the utility arm and dressier in appearance and are likewise a poor substitute for a normal hand. They are usually heavy and the weight is at the wrong end of the appliance.

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## XVI. INFECTIONS AND TUMORS OF BONE

### ACUTE OSTEOMYELITIS

This term has come into general use and will probably continue to be the name generally accepted as designating an infection that may involve the entire bone—periosteum, cortex, medulla epiphyseal line shaft and epiphysis and including in its meaning similar pathologic lesions in all bones whether long, irregular or flat. In its narrow sense the word osteomyelitis was and sometimes is confined to infection of the medullary canal and the adjacent bone, and because the term is not very accurate many other titles have been suggested—*periostitis*, *osteoperiostitis*, *periosteomyelitis*, *osteitis*, *epiphysitis* etc., but in spite of objection and suggestion the term osteomyelitis is more and more used in its broad sense.

There are two exceptions to this nomenclature that are in more or less general use. If the infection is confined to the periosteum it is spoken of as *periostitis*, and where the infection is definitely within the bounds of cancellous bone most surgeons use the term *osteitis*. However, there is much confusion and looseness in the use of terms to designate infectious processes in the different elements that enter into the structure of bone.

**History**—Because many of the bones are near the body surface infections in them have been seen and discussed from the beginning of recorded surgical observations and many famous names are associated with the progress of understanding of the various phases of acute osteomyelitis. However in spite of the great mass of literature dealing with all phases of bone infection acute osteomyelitis still remains a disease that is often diagnosed too late to be treated promptly enough to prevent a high mortality rate, long illness, serious complications, permanent deformity and great economic loss.

**Anatomy**—The long flat and irregular bones have a somewhat different arrangement of the elements that enter into their structure. All of these elements—periosteum, endosteum, articular cartilage, compact and cancellous bone, epiphyseal line and cartilage, medullary canal and contents, haversian system and cortex together with the blood and lymph supply should be borne in mind. The differences in bone during body growth and in adult life must be considered. The relationship of bones to joints also enters into the anatomical problem.

The structure of the different bones is described in any good textbook of anatomy. There has been a great deal of controversy however as to the behavior of the periosteum and the arrangement of the blood supply. It is important to know just how bone renews itself when destroyed by disease, damaged by trauma or excised by the surgeon and there is considerable literature descriptive of the results of experiments on animals and observations on human bone during repair. Likewise there are a number of excellent studies of the blood supply of bone including that of Lexer and of Robert W. Johnson.

The periosteum has two surfaces, an outer fibrous one covering the bone and separating it from surrounding structures and an inner one loosely attached to the bone by many fine strands of connective tissue. This attachment is much less firm in children than in adults and especially so in children under two years of age. It is around this deeper layer that controversy has been waged as to what part it plays in the repair of bone. When torn away by trauma or lifted up by infection many osteogenic or bone-forming cells go with it and these cells play a major part in the formation of new bone. The periosteum covers the shaft of the long bones and is firmly attached to the cortex at the epiphyseal line but is not continuous with the articular cartilage. In young persons it dips down into the bone at the epiphyseal line. In the growing child the epiphyseal line is made of cartilage from the shaft side of which the bone grows in length. Because of this fact there is not very firm union between the shaft and epiphysis and separation due to trauma is common at this point. In young persons the blood supply is abundant along this line and comes from a number of directions—chiefly from the nutrient artery of the shaft and almost as abundantly from the side of the epiphysis where the blood enters the bone chiefly from a circular network of arteries just outside of and surrounding the articular cartilage. A third source of blood supply is from the periosteum but this supply is now known to be of less importance than was formerly supposed. When the blood vessels of young bones are injected a very beautiful and abundant network of end arteries is seen on either side of the epiphyseal line.

It was formerly supposed that the stripping up of the periosteum resulted in necrosis of the underlying bone because of interference with the blood supply but observation and experiment have established the fact that necrosis is caused by infection which kills the bone either by direct damage to the cells or by widespread embolism and thrombosis of the blood vessels.

The nutrient vessel in the long bones of the two extremities runs toward the elbow and away from the knee. This vessel divides soon after entering the bone and sends a main branch in either direction. The rich circle of blood vessels found in the expanded

ends around the articular cartilage are intimately associated with the epiphyseal line especially in those joints where the articular cartilage approaches close to the epiphyseal line and where the synovial membrane of the joint may overlay the junction between shaft and epiphysis.

**Etiology.**—Acute osteomyelitis is the successful invasion of bone by pyogenic micro-organisms, chiefly *Staphylococcus pyogenes aureus* (which is the organism at fault in about 75 per cent of the cases), the streptococcus *Staphylococcus albus*, the colon bacillus, the pneumococcus and very rarely the gonococcus. The typhoid bacillus is occasionally found but is associated with sub-acute and chronic osteomyelitis. These organisms are for the most part blood-borne, and the type of osteomyelitis which they produce is called hematogenous. There are several other avenues of infection however. Compound fractures or operations on bone followed by infection may cause osteomyelitis. Very rarely the bone may become infected by contiguity from a neighboring joint, or acute osteomyelitis may be secondary to infection in neighboring soft parts, osteomyelitis of the lower jaw is a very common complication of infected gums or tooth sockets and whitlow is complicated by infection of the terminal phalanx. Some infection of rib ends may follow thoracotomy, and perforating ulcers of the foot are apt to involve bone and periosteum. If the osteomyelitis is hematogenous and due to *Staphylococcus aureus*, the source of infection should be looked for in the skin—furunculosis, carbuncle, acne, infected fistulas etc. If, on the other hand the streptococcus is the causative organism, the original site should be sought in the mucous membranes of the mouth or nose, the tonsils or accessory sinuses. The pneumococcus is found in the blood stream in pneumonia occasionally bones or joints become the seat of a pyogenic infection and rarely the colon bacillus found in suppurations within the abdomen may enter, by way of the blood into osseous tissue.

**Pathology.**—Until recently the conception of the pathologic anatomy of this condition was cloudy and confused because the beliefs expressed long ago by surgeons and pathologists were accepted without being subjected to careful observation. Recently a number of investigators have helped to make clear

just what happens when bone is acutely infected. A number of things must be borne in mind. The youth of the patient largely influences the blood distribution the avenue of infection is important, the haversian canals and the bone between the periosteum and its loose attachment to the cortex the epiphyseal line and the break in periosteum at this point the medullary canal and its contents the endosteum the kind number and virulence of the infecting organism and the resistance of the host and predisposing factors such as trauma and exposure to cold all of these elements must be considered when one is confronted with a pathologic process that may begin with dramatic suddenness develop with amazing speed and end in tragedy almost before it is realized that anything serious is happening.

While the periosteum is usually involved in osteomyelitis as a part of the later spread of the infection throughout all the elements of the bone primary acute periostitis is in most instances a local process associated with trauma and confined to the periosteum and a thin layer of cortex. There is one type of primary severe acute periostitis however that is very destructive of the underlying bone and that is caused by trauma and local infection in the soft parts successfully invading the subperiosteal space and leading to widespread separation of periosteum and infection of bone which may cause sequestration of the entire shaft. The writer has seen the entire metacarpus of the ulnar lost in a case in which infection resulted from a break in the soft parts caused by treating a wart just below the elbow with strong nitric acid.

Localized infection of all the bony structures often follows compound fracture and is seen also as a complication of open reduction of fractures. This kind of infection however is not apt to be so virulent rapid or destructive as the hematogenous type when there is no fracture of bone or extension from a neighboring joint but an acute infection brought from some distant source in the body in the blood stream.

It is often impossible to say whether the disturbance in any given case begins as the result of the deposit and multiplication of organisms in the bone or whether the infection begins as one or more infarcts secondary to emboli and thrombosis. The very rapid and extensive involvement of bone in hectic thrombosis in the larger branches of the nutrient artery or in the blood vessels at or near the epiphyseal line.

In acute hematogenous osteomyelitis the process commonly begins in the shaft of the bone near the epiphysis. Often it appears that the infection begins in the line of the epiphysis itself and for this reason the term acute epiphysitis is sometimes used. It is the very rich blood supply in growing bone that accounts for this behavior. Sometimes there will have been a preceding trauma with some injury to the epiphyseal line such as partial separation or hemorrhage.

If the point of infection is near the epiphyseal line it may break through the bone at this point and reach the periosteum. If drainage is instituted within a few hours of the onset of the infection recovery may take place before there is much detachment of periosteum or any extensive involvement of the shaft and before the medullary canal is infected. If the infection is massive involving a considerable area of bone the

periosteum will be detached over a large surface and the infection will travel through the bone to the medulla and thence along the medulla.

It is in these severe cases that the full damage to bone is seen—despread necrosis with large areas of detached periosteum and extensive involvement of the medulla. It was thought for a long time that the chief avenue of infection was along the medullary canal but Starr showed that the infection begins in the marrow of the cancellated bone of the metaphysis and that it spreads along the epiphyseal line to the periosteum elevating the periosteum and extending along the surface of the cortex through which it invades the haversian system and reaches the medulla. Therefore the medullary canal instead of being invaded early and acting as the chief avenue of widespread infection is often the last of the bony structures to be invaded. Somewhat later the periosteum is broken through and pus may be found collected in pools in the medulla in the cancellated bone under the periosteum and in the soft tissues outside the periosteum. Extension through the epiphysis into the neighboring joint is much less common than would be expected.

In many of these patients the infecting organism can be recovered from the blood stream. Sometimes the septicemia is overwhelming and death may occur from forty-eight to seventy-two hours after the onset of local symptoms. More often the infection although very rapid and severe causes widespread local destruction of bone and later distant complications develop as a result of blood stream infection such as involvement of another bone suppuration in a distant joint, suppurative pericarditis or empyema. In acute osteomyelitis especially in the severe diffuse type a definite train of events follows the acute process unless early diagnosis and prompt treatment are followed by localization of the infection. Because of severe infection and a disturbed circulation more or less extensive necrosis of bone takes place. The raised periosteum carrying with it the osteogenic layer soon begins to lay down new bone which surrounds the dead portion of the shaft. The separation of devitalized bone from the living bone is called sequestration and the mass of dead bone is called a sequestrum. Because it is dead the sequestrum becomes an infected foreign body around which suppuration continues and the pus escapes to the surface through openings in the involucrum called cloacae.

**Predisposing Factors**—Acute osteomyelitis is a disease of the young. Most cases occur in children from two to twelve years of age. There is often a definite history of trauma especially when the disease occurs at or near the junction of the shaft with the epiphysis. Exposure to cold seems to play some part by lowering the local resistance. Boys are affected more often than girls the proportion being three or four to one. The femur tibia or humerus is usually involved. Most reports give the lower end of the femur the highest incidence but in the writer's ex-

perience the lower end of the tibia has been more often affected. It is sometimes stated that this disease is more common in the late winter and early spring and the writer's experience supports this opinion.

Acute infection of the mandible is common and at times very destructive. The infection reaches the bone along the tooth sockets and may follow almost any dental procedure from extraction to cleansing of the teeth. It may be latent but often is directly introduced by unclean work. Any chronic infection of the skin or mucous membrane may be the source from which emboli enter the blood stream and lodge in the bone.

**Clinical Varieties**—There is the very acute destructive and extensive infection of all elements of bone confined usually to the shaft. This is the acute diffuse osteomyelitis described by Phemister.

Another type is the so called acute epiphysitis seen in the young in which the infection begins at or near the epiphyseal line and breaks through to the periosteum early. If the diagnosis is quickly made and proper drainage is obtained little involvement of the metaphysis and not much lifting up of periosteum result.

There is also the relatively less acute infection of the bone ends seen in compound fractures or infection of the bone following open reduction with the use of wire plates or nails to fix the fragments. There is also acute localized osteomyelitis confined to a small area of the medulla or of the cancellated bone of the shaft or of the epiphysis. There is a rather sharply localized infection leading to necrosis and suppuration and resembling an abscess in its general behavior. Such an infection is not very severe; it usually causes local pain tenderness and disability and if neglected may spread more widely. Following drainage if the area of necrosis is large there will often be left a long standing infected sinus leading down to a bone cavity that fills in either very slowly or not at all.

Garre described an acute diffuse sclerosing osteomyelitis in which there is little suppuration but considerable sclerosis with small areas of necrosis. Such an infection almost always becomes chronic and may continue more or less active for years.

Osteomyelitis may begin in the sacrum or vertebrae and bring about a confusing symp-

tomatography. In the early stages roentgenograms are negative the symptoms are those of infection and the signs point to meningitis. Careful spinal puncture may demonstrate the presence of pus between the bony canal and dura and clear fluid in the subdural space. Prompt drainage of the extradural space is indicated. There have been seven cases in the service of Dr. M. C. Pincoffs and his associates with five recoveries and two deaths. Three of these have been reported.

**Symptoms.**—In acute osteomyelitis the onset is sudden sometimes followed by such rapid progress of the disease that delirium and coma may supervene before localizing signs and symptoms are evident. This is not usually the case but many children are desperately ill from the very beginning of the infection. Sometimes the onset is surprisingly like that of pneumonia beginning with a short period of malaise followed by a chill with high fever, rapid pulse and a sharp elevation of the leukocyte count. The face is florid and there is profuse sweating, restlessness and anxiety. In pneumonia the local signs are in the lungs and in osteomyelitis they are in one or more bones. The outstanding symptom is local pain which is continuous, deep, boring and severe and the outstanding sign is exquisite tenderness on pressure over the bone with increase in discomfort brought out by tapping along the shaft of the affected bone.

In the early stages there will be no involvement of the soft parts outside of the bone. The infection as already indicated usually begins in the end of the shaft close to the epiphysis and the manner of onset, the absence of evident redness and swelling and the nearness of the pain to a joint will usually cause loss of valuable time in arriving at a correct diagnosis. It is unusual for surgeons even in large clinics to see patients with acute osteomyelitis early enough to prevent sequestration and long illness and disability.

In acute cases after twenty-four hours there will often be some edema and tenderness in the soft parts over the end of the involved bone and if the patient is still not treated suppuration will usually develop in the soft tissues adjacent to the bone end. This occurs after the infection has broken through the periosteum.

By this time the patient is very ill with high fever, rapid pulse, dehydration and exhaustion from pain, lack of sleep and infection. Very often there will be vomiting with disturbance in the acid-base balance and often delirium if not coma. The leukocyte count is usually very high.

A careful history often uncovers the presence of predisposing factors as well as possible sources of infection. There may have been some infection of the skin or subcutaneous tissues, a fistulous tract or an ulcer in which case the staphylococcus is suspected or there may be a history of nose or throat infection with involvement of the accessory sinuses, middle ear or mastoid in which instance the streptococcus is apt to be at fault. These patients are usually children and it is sometimes difficult to establish any previous history of trauma or chilling. In many instances blood cultures taken at this time are positive.

There are a number of complications that are likely to occur. A second bone may be involved or there may be extension of infection into a distant joint as in pyemia, suppurative pericarditis is occasionally seen and may easily be overlooked. If the blood stream becomes infected the symptoms are modified in accordance with the kind of organism that is present. If the septicemia is due to the streptococcus the pathology and symptoms are typical of this infection—very acute and develop rapidly, the fight is apt to be won or lost quickly.

If *Staphylococcus aureus* or more rarely *albus* is at fault the progress will be relatively slow with a tendency to multiple joint suppurations, irregular chills and wide variation in the range of temperature with possible suppuration in the serous cavities. This tendency to prolong the pathology and symptoms is seen in any typical case of pyemia, does not improve the prognosis over that of streptococcal septicemia. In both the outlook is unfavorable.

Roentgenograms are of no positive value in the early diagnosis of acute osteomyelitis and negative findings may give a false impression of security. It is not until necrosis begins to be evident in the bone or the periosteum is lifted up that the x-ray picture is of any help, usually from four to seven days elapse before these changes are evident.

In the later stages of acute osteomyelitis the x ray picture is of great value in estimating the amount of necrosis and the progress of sequestration together with the extent and density of the involucrum, but all of this is far removed in time from the onset of the disease.

The early diagnosis of acute osteomyelitis is a matter of great difficulty. Many good clinicians who are keen and prompt in the diagnosis of other acute infectious diseases are often slow in making a diagnosis of acute osteomyelitis. Because of the close proximity to joints the diagnosis of acute infectious arthritis is often made, scurvy is sometimes considered and because a child does not move the affected limb poliomyelitis is suspected. After the soft parts are involved a diagnosis of rheumatic fever, erysipelas, cellulitis or lymphangitis may be made.

If a child complains of pain over the end of a bone and is loath to move the limb, if there is tenderness on deep pressure over a bone as well as symptoms of an acute infectious process, if the onset of these signs and symptoms has been abrupt and if the evidences of infection are rapidly on the increase a diagnosis of acute osteomyelitis should be made and treatment begun immediately. Any delay invites disaster.

**Treatment.**—There have been two distinct schools of thought and practice regarding the time factor as applied to the treatment of acute osteomyelitis. One group advocates waiting from five to seven or nine days until the infection has localized and drained into an abscess in the soft parts. Another group is convinced that the infected bone should be drained as soon as possible but believes that the operation should be one of drainage and confined to the area of infected bone.

A number of reports are coming into the literature advocating the waiting method with later drainage especially in children under two years of age. Chemotherapy, bacteriophage vaccines and transfusion together with supportive treatment may limit the operation to the need of drainage of the soft parts only with later resolution without sequestration in a number of instances. The number of surgeons who lean toward this latter more conservative treatment is rapidly

increasing because of recent advances to be discussed in the following paragraphs.

Under the head of *chemotherapy* two very great advances have been made in the treatment of osteomyelitis—the sulfa drugs and penicillin. These two agents are apparently revolutionizing the method of treatment of bone infections. The sulfa drugs were first in the field. In the main sulfanilamide is more useful in the treatment of streptococcus infections while sulfathiazole is a better agent in combating staphylococcus bone infection. Sulfadiazine is apparently almost equally valuable in either streptococcal or staphylococcal infections. This should be the drug of choice when it is impossible to determine the bacterium present.

Until penicillin became more readily available the sulfonamides were widely used in osteomyelitis especially in the acute forms. If treatment was begun early before extensive necrosis of bone or raising up of the periosteum by liquid exudate in a fair number of instances the giving of sufficiently large doses of the sulfonamides under careful blood level checks was followed by absence of either sequestration or extensive bone necrosis although in many instances repeated x ray examinations showed widespread reaction of bone to infection. As in other infections these agents are used either by mouth or intravenously depending upon the acuteness and extent of the infection.

Penicillin has so recently become widely available in civilian hospitals that there are very few reports at hand in which the observations of osteomyelitis have been followed through until final cure of the disease has been effected. Certain it is that this agent is most valuable and efficient in the treatment of osteomyelitis whether acute or chronic, localized or extensive, single or multiple or associated or not associated with a demonstrable blood stream infection. Many surgeons are hopeful that this agent is the solution of the disabling and death dealing disease *acute hematogenous osteomyelitis*.

Our experience however seems to suggest the warning that in some instances at least serious symptoms, blood stream infection and spread of osteomyelitis are kept in check while penicillin is being administered and that when the drug is stopped all of the



cal signs and symptoms recur. Oral administration requires large dosage. The most used avenues of medication are intramuscular and intravenous. In osteomyelitis, when treatment should be continued for a number of days at least, probably the better method of the two is by muscle. This presumably creates a reservoir of the drug whereby the drug is continuously absorbed. Penicillin is excreted rapidly, chiefly by the kidneys and in the intramuscular method of administration we give 10 000 units every three hours for an average total of 1 000 000 units which requires something more than twelve days. We give the same dose to children. If the urgency is very great we may do one of two things, either give the drug intravenously by constant drip so that the patient gets from 80 000 to 100 000 units each twenty-four hours or augment the intramuscular method with an initial intravenous dose of 90 000 units. By both avenues penicillin is dissolved in normal salt solution in preference to distilled water as we believe this method is less painful. We have noticed no evidence of shock and very few minor reactions.

If operative intervention is decided upon the problem is one of drainage with as little destruction of bone as possible with as little spread of infection as possible and with the saving of periosteum because it is from the osteogenic layer of the periosteum that most of the repair is to come. The medullary canal is involved later than the cancellous bone and periosteum and should not be opened unless it is already infected since exposing the medulla to infection may lead to extension of the infection along this canal.

If the diagnosis of acute osteomyelitis is reasonably well established the patient should be treated promptly for shock, the dehydration should be combated and the blood stream infection should be treated by transfusion. Chemotherapy may change very materially the treatment of osteomyelitis. There are a number of difficulties in the way at present, however, one of which is the delay in determining the infecting organism and another is the toxic effect of these agents in large doses. Perhaps a single drug efficacious for both staphylococci and streptococci will be speedily available.

If operation is undertaken the infected bone should be exposed, care being taken to avoid blood vessels and nerves and not to open tendon sheaths or the synovial membrane of the neighboring joint. If the soft parts are intact an incision should be made through them down on the periosteum. If the periosteum is not involved it should be incised and a small hole drilled into the bone, keeping close to the epiphyseal line in the long bones and making the opening on the side of the metaphysis. Pus is almost always found in the cancellous bone close to the epiphyseal line and at an early stage the medullary canal is not involved. However it is not often that a patient comes to operation so early. More commonly the periosteum is found to be elevated with pus between it and the bone and by that time the medulla is infected and requires drainage. As little damage to the bone as possible should be inflicted. A number of small openings should be made so as to drain the bone and the canal. It is most important not to gouge out bone with a sharp curet and it is equally important not to damage the contents of the medullary canal. Drainage is all that is needed at this stage.

If the patient is young and the epiphyseal line is involved it is most important to safeguard the limb against pathologic epiphyseal separation as this mishap causes deformity and complicates the entire problem of treatment and convalescence.

Probably the best method of supporting an ill patient through the first few weeks of acute osteomyelitis is by means of repeated small blood transfusions. Many reports indicate that this procedure often seems to turn the balance in favor of recovery.

Treatment does not end with drainage of the infected bone. The limb must be safeguarded and cared for and the patient treated through a long convalescence. Support of the damaged limb is essential and repeated dressings have many disadvantages. The Orr method or some modification of it will meet most of these requirements. The length of time that elapses before recovery is complete varies from a few weeks to many years; this is determined by a number of factors, by far the most important of which is early diagnosis followed by prompt and efficient drainage. If physicians were as keen in dealing with

this condition as they are in most other fields the story would be a different one

ARTHUR M. SHIPLEY

## CHRONIC OSTEOMYELITIS

Chronic osteomyelitis is one of the great trials of surgery. As a result of late diagnosis most patients with acute osteomyelitis become victims of chronic bone infection. There are many problems that must be met and combated. It is a long and disabling malady which causes great economic loss because of hospitalization, nursing and home care which interferes seriously with the child's education and in the adult results in an extended period of inability to work. These circumstances together with deformity and the likelihood of complications make this disease a major disaster fraught with anxiety for all concerned.

**Pathology and Course**—If only one epiphyseal line is destroyed in a child the growth of that bone may be satisfactory provided the infection is checked and controlled. Fracture or epiphyseal separation during the early stages of chronicity before the involucrum is solid may occur. Unless continuous care is taken there will be deforming contractures of neighboring joints. The slowly healing granulation tissue is apt to be the avenue for repeated infections some of which may be severe—erysipelas, cellulitis or tetanus. Even after the open wound is healed the scar is thin, adherent and easily injured. Many patients with old osteomyelitis have recurrent attacks during which there is a lighting up of the infection. Months or years after apparent quiescence and healing a fresh infection breaks out either at or close to the original disease or in a distant bone. Epidermoid carcinoma may develop in the scar (Marjolin's ulcer).

If suppurative arthritis complicates the bone infection, more or less ankylosis is apt to occur and unless care is taken the joint will become fixed in an unsatisfactory position which will require some type of joint repair or corrective osteotomy. These chronically infected persons suffer the effects of lowered resistance and fall an easy prey to almost any malady. Added to all this a chronically disabled person may develop some type of insufficient personality and

even after being returned to fairly normal health may be unable or unwilling to carry on.

Chronic osteomyelitis may occur without preceding acute damage. The infection may begin as a subacute process in bone due to *B. typhosus*, a complication of typhoid fever which appears late in the illness or long after the patient is apparently recovered. The ribs are a favorite site for this infection. Local application of typhoid vaccine is helpful in the treatment. A localized chronic bone infection for example *Brodie's abscess* may occur without previous acute osteomyelitis and is due usually to a staphylococcus. Localized chronic collections of pus in bone however are very commonly seen as a late occurrence in hematogenous osteomyelitis. These areas of necrosis are due to latent infection and may be seen for months or years after the original infection has apparently healed.

Just where the dividing line in time between acute and chronic osteomyelitis is placed depends largely on the individual surgeon. Certainly in most cases of osteomyelitis when first operated on the patient is already in the early stage of chronicity that is the operator knows that the patient will require adequate drainage, immobilization, safeguarding against reinfection and all possible supportive measures because the condition is certain to be long drawn out involving necrosis, elimination and repair. These changes must take place in bone where most changes take place slowly so that progress is measured in months and years instead of in days and weeks as in many soft tissues.

**Treatment**—Chronic osteomyelitis is at best an unsatisfactory and disappointing disease to treat. Failure to effect a cure has led to the trial of a number of procedures and one is confused rather than encouraged by reading the literature. The care of a patient with chronic osteomyelitis is a serious problem. There is the expense and trouble of repeated dressings, the exposed area is repeatedly reinfected, there is the risk of distant complications and the bone at the site of infection may suffer a pathologic fracture. In children joint contractures are liable to occur. The long convalescence during which there is more or less absorption of toxins is

a heavy physical strain and the mental attitude of the patient is apt to be most unhappy. The sulfonamides and penicillin are much used in chronic osteomyelitis often with excellent results provided sequestra are removed and collections of pus drained.

The pathology during the acute stage is a determining factor—the extent of the stripping up of periosteum, the length of the medullary canal invaded and the amount of bone infected. If there is complete sequestration with rapid formation of involucrum the generally accepted method of treatment is to safeguard the bone from pathologic fracture and the neighboring joints from contracture and the drainage is ample and to wait until the sequestrum is completely separated and the involucrum reasonably firm in the meantime aiding the reparative mechanisms by every means available—transfusions, open air, sunlight, proper food, tonics, good nursing, etc.

After sequestration is complete and the involucrum sufficiently firm to take over some of the functions of the dead bone, sequestrectomy is indicated. This type of late operation in osteomyelitis in the chronic stage should be done with care and precision. The loss of blood is sometimes alarming and is always a factor to be considered. If possible the actual operating should be done with a tourniquet placed above the operative field. Great care should be taken to disturb the involucrum as little as possible and the periosteum should be saved to the fullest extent because the osteoblasts are essential to the formation of new bone. Whenever chiseling must be done in order to release the sequestrum or to insure better drainage care should be taken to destroy as little good bone as possible because wherever fresh bone is exposed to infection a new process of bone necrosis is set up and there is another long wait for sequestration to occur.

Regarding the operation itself there are two schools of attack—the radical and the conservative, each can point to victories and both have suffered defeats. The conservatives limit early operating to securing and maintaining drainage with the least possible removal of bone until sequestration is complete. The more radical operators remove considerable areas of infected bone, make a gutter of the entire length of the involved

shaft and leave the wound in the overlying soft parts wide open. This produces a large heavily infected area and it is difficult to prevent reinfection and to get rid of necrotic tissue. Complete subperiosteal resection of the entire area of infected bone has been practiced but this causes a long period with little bony support while the involucrum is forming. There are several distinctly different methods of dealing with these cases and each has outstanding advantages.

If it becomes necessary to open and drain infected bone the Orr method overcomes many of the dangers and difficulties of repeated dressings at short intervals. Briefly his method may be described as follows: The limb is immobilized on a traction table and the infected bone is opened for adequate drainage. The wound is opened widely both in the bone and in the soft parts. The entire wound is filled with a vaselin gauze pack which projects over the wound edges and is covered by a dry absorbent dressing. The limb is then immobilized in plaster; the cast should be snug and extensive enough to control muscle spasm and prevent pathologic fracture and joint contractures. These dressings may be left undisturbed for from four to eight weeks.

The writer has followed this plan and found it very efficient. The one objection is the odor from the unchanged dressings continuing the wound discharge. The cast may be changed oftener than Orr advocates but when the amount of discharge becomes less the odor also is less in evidence. Certainly the infection in the soft parts clears up very rapidly and the patient in the meantime is comfortable. He is also saved the expense and pain and risk of daily dressings. The greatest advantages are the relative freedom from reinfection of the wound and the absence of the destruction of the elements of repair brought about by the trauma of repeated dressings. Bacteriophage chemotherapy and vaccines are at times helpful.

Chronic osteomyelitis is often seen as a complication of compound fractures especially in comminuted fractures where there has been extensive exposure of overlying soft parts to infection and where early excision of the wound has been carelessly done. When chronic bone infection is established the treatment is usually largely ex-

pectant The fracture is adequately treated so as to overcome overriding angulation and rotation and the infected area is drained just enough to allow the free escape of infected and necrotic material Some of the bone usually becomes separated and requires removal usually causing delayed union The utmost patience plus drainage with immobilization will in most instances insure a good although considerably delayed result The untoward factors are chronicity atrophy of unused muscles and stiffness in the immobilized joints and these unsatisfactory end results are in direct ratio to the duration of the convalescence and the age of the patient In comminuted compound fractures followed by infection bone fragments may become completely loose in the tissues and will be the chief cause of persistent sinuses until removed

ARTHUR M SHIPLEY

## TUMORS OF BONE

The variable aspects of tumors of bone often make it difficult to decide on the diagnosis and the form of treatment The age of the patient the duration of symptoms the number of bones affected and the roentgenograms are of importance in making a decision In patients under ten years of age the most frequent solitary tumor is a bone cyst (usually in the upper part of the humerus) and Ewing's sarcoma (most often in the shaft of the femur or tibia) Christian's disease of bone or some metabolic deficiency such as rickets or scurvy is one of the commoner multiple skeletal diseases of childhood

The symptoms of pain and swelling extend over a period of several weeks or months in cases of bone tumor On the other hand in osteomyelitis acute symptoms may develop within a few days When the history of a bone tumor dates back several years some unusual complication must be present

Multiple tumors of bone are usually benign in children and malignant in adults Among the multiple tumors of adults the benign condition diffuse osteitis fibrosa with hyperparathyroidism must be borne in mind as a possibility although the probabilities may favor metastatic carcinoma

In the interpretation of the roentgenogram it is well to have for examination both anteroposterior and lateral views and when feasible a roentgenogram of the opposite normal bone for comparison Where there are multiple foci of involvement in a single bone roentgenograms of the pelvis skull and chest should be made Malignant tumors of bone are prone to invade all of the regions or zones depicted in the film Bone destruction or bone production or both will invade the marrow cavity, the cortex the periosteal region and the overlying soft parts Benign tumors are most often limited to a medullary cortical or subperiosteal origin When bending deformity is seen in the affected bone it is an important sign of benignity

The Wassermann reaction and the leukocyte count are always important In rare instances the diagnosis may depend on blood calcium and phosphorus determinations on estimation of the total plasma proteins or on examination of the urine for Bence-Jones bodies

Biopsy of bone is a safe and valuable procedure when competently done and amputation should not be performed without confirming the diagnosis by this method

The microscopic features of bone tumors cannot be adequately interpreted without reference to normal histogenesis In the skeletal tissues three phases of osteogenesis exist with corresponding tumor formations In the most primitive the cycle of development passes from precartilaginous connective tissue through fetal and adult cartilage to the calcified state To this fibrocartilaginous series belong chondrosarcomas chondroblastic sarcomas chondromas and osteochondromas Following calcification a resorptive phase appears in bone characterized by proliferation of giant cell osteoclasts To this series of changes belong the growth known as giant cell tumors solitary bone cysts (a restorative or healing phase of giant cell tumor) and multiple cystic disease known as von Recklinghausen's osteitis fibrosa cystica Finally there are the steps passing from connective tissue through osteoblasts to bone resulting in true bone formation which may be termed the fibroosseous series In the membranous bones this is the only series of developmental changes observed To these phases belong sclerosing

and osteolytic osteogenic sarcomas, as well as osteomas of the jaw and skull bones.

from without To the precursors of the lymphoid elements of the haversian systems

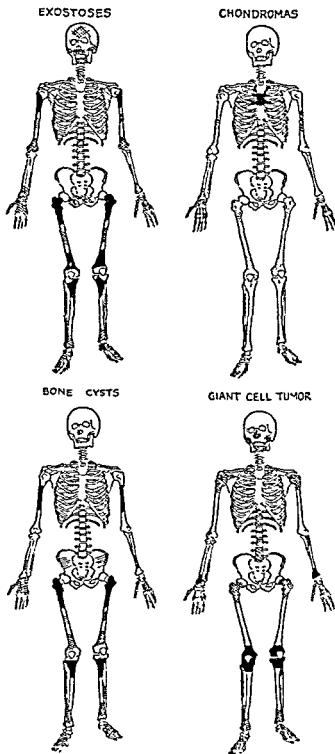


Fig 282—Charts showing the skeletal sites involved in benign tumors of bones. The solid black areas indicate the most frequent sites, the checked areas indicate the common sites and the diagonal lines indicate the occasional sites.

Non-osseous lesions arise from the marrow and haversian systems or invade the bone

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pectant The fracture is adequately treated so as to overcome overriding angulation and rotation and the infected area is drained just enough to allow the free escape of infected and necrotic material Some of the bone usually becomes separated and requires removal usually causing delayed union The utmost patience plus drainage with immobilization will in most instances insure a good although considerably delayed result The untoward factors are chronicity atrophy of unused muscles and stiffness in the immobilized joints and these unsatisfactory end results are in direct ratio to the duration of the convalescence and the age of the patient In comminuted compound fractures followed by infection bone fragments may become completely loose in the tissues and will be the chief cause of persistent sinuses until removed

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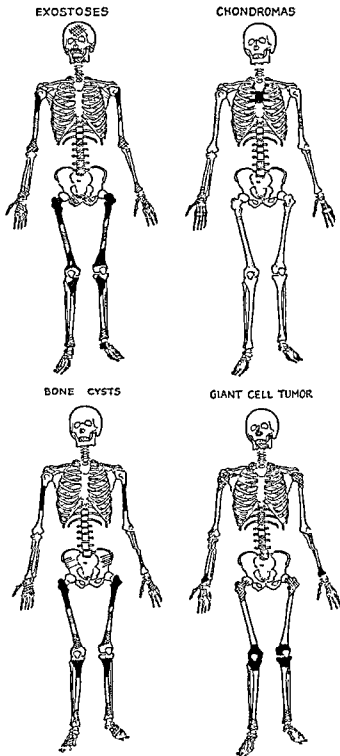


Fig 282—Charts showing the skeletal sites involved in benign tumors of bones. The solid black areas indicate the most frequent sites; the checked areas indicate the common sites and the diagonal lines indicate the occasional sites.

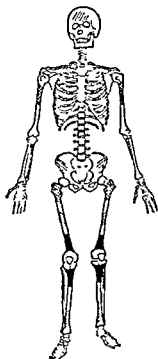
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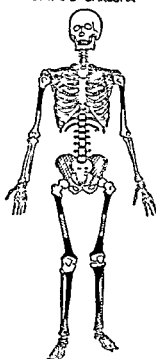
ments, multiple myeloma, chloroma and Christian's syndrome (xanthomatosis). In

various types of metastatic tumors from the breast, prostate, kidney, lung, thyroid, etc.

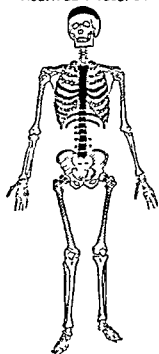
OSTEOGENIC SARCOMA



EWING'S SARCOMA



MULTIPLE MYELOMA



METASTATIC CARCINOMA

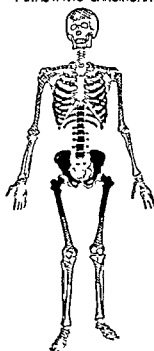


Fig 283—Charts showing the skeletal sites involved by malignant tumors of bones. The solid black areas indicate the most frequent sites, the checked areas indicate the common sites and the diagonal lines indicate the occasional sites.

the marrow cavity also via vascular and lymphatic channels there are deposited the

Fascial and neurogenic tumors may invade bone from the neighboring soft parts



In treatment rest of the part is obtained by splinting, by the use of crutches or by putting the patient to bed and is important in relieving pain and preventing pathologic

coma may show favorable results following irradiation Deep x ray therapy or teluradium is preferable in the treatment of bone lesions to implantations of radon or radium salts

#### CLASSIFICATION OF BONE TUMORS

##### 1 Tumors of Osseous Origin

Fibrocartilaginous	Resorptive series	Fibro-osseous series
Osteochondroma Chondroma Chondroblastic sarcoma Chondrosarcoma	Giant cell tumor Bone cyst Diffuse osteitis fibrosa	Osteomas of skull and jaws Sclerosing sarcoma Osteolytic sarcoma

##### 2 Tumors of Non Osseous Origin

Marrow and haversian systems	Metastatic deposits	Invasion by direct extension
Ewing's endothelial myeloma Multiple myeloma	Carcinoma of prostate breast kidney etc	Fascial sarcoma Neurogenic sarcoma etc

fracture Resection rather than amputation will often suffice for radical removal of a tumor in a bone of the arm or in the fibula The value of irradiation in reducing the size of the tumor or in relieving pain in Ewing's

Osteochondroma—The most common tumors of bone are the benign osteochondromas These tumors often referred to as exostoses produce bony outgrowths near the ends of the long bones which are exaggerated

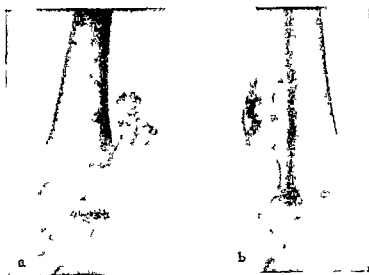


Fig 881—Roentgenograms showing two views of an osteochondroma in a boy of fifteen years at the site of the adductor tubercle in the lower femur The features of the growth depicted in these roentgenograms are typical

sarcoma multiple myeloma and metastatic carcinoma must be borne in mind as well as its usefulness in accomplishing a cure for such conditions as angioma and giant cell tumors Chondroblastic and osteolytic sar

tions of normal bony protuberances, forming the attachments for important ligaments and tendons Although such growths are commonly discovered in young adults under twenty five, the tumors in most instances

grow during adolescence from a congenital focus. Osteochondromas resulting from trauma are rare. Gradual growth unaccompanied by severe symptoms is the rule. Mild pain, stiffness or swelling alone is present, and many of these cases are accidentally discovered on roentgenographic examination. The tumor is hard, nodule and fixed to the underlying bone. The x-ray picture shows a cauliflower like mass with a lobulated translucent top and beneath an osseous pedicle or base which fuses with normal cortical and cancellous bone (Fig 281). Calcified particles stipple the periphery of the



Fig 283—A benign osteoma of the skull in an adult which was preceded by trauma. The roentgenogram depicts an intact inner table and an outward proliferation of radiating spicules which elevate the periosteum. The bone formation is occurring directly in fibrous tissue.

lesion, and in rare instances a bursal sac with fluid and calcareous material forms. Under the microscope the outermost layer of the growth shows strands of primitive connective tissue encapsulating and dipping into the underlying cartilage. Proceeding from this capsule to the osseous base in their order of appearance are zones of fetal, adult and calcifying cartilage, newly formed bone and adult spicules interspersed with fatty marrow.

Osteochondromas are rare outside of the long bones and pelvis. An occasional one is found at the occiput, in the spine or in the

scapula. The maximum diameter of the lesion varies between 2 and 8 cm., and the growth proceeds slowly to final arrest at about the age of twenty-five. These are important features in the diagnosis. Osteomas occurring in the frontal bone, the jaw or the sinuses show ossification in fibrous tissue and do not contain cartilage (Fig. 285). They may grow rapidly but do not undergo malignant change. They have an age incidence similar to osteochondromas. Sometimes these growths of membranous bone follow trauma and during active development contain a cellular fibrous stroma (so-called ossifying fibromas) and may be erroneously classed as fibro-sarcomas. These more cellular tumors may appear in childhood. Osteophytes seen in arthritis have a similar distribution to osteochondromas but occur more often in elderly adults. They are small (rarely exceed 1 cm. in their greatest dimension) and are usually multiple on either side of the joint. Osteochondromas which in adults grow rapidly and exceed the size of an adult fist must be regarded with suspicion and have usually undergone malignant change.

A single osteochondroma of moderate size with slow growth and few symptoms may be left untreated. It is well to have an x-ray examination to check the growth every year or so after the age of thirty. Simple excision may be performed for the osteochondromas which produce pain or dysfunction. Osteochondromas are not influenced by irradiation.

**Multiple Exostoses**—One or more simple osteochondromas may occur in a long bone without distorting the entire extremity. This, however, is rare. When more than one such growth is depicted in the roentgenogram, there are usually similar growths elsewhere accompanied by cartilaginous lesions within the cancellous spaces. Numerous deformities throughout the entire skeleton result from multiple growths of this type. This condition is congenital in origin, and frequently several members of the same family running through more than one generation are affected. This combination of exostoses and enchondromas is referred to as hereditary, deforming chondrodysplasia and sometimes as Ollier's disease. All the bones derived from cartilage may be affected. Bowing of the arms and legs occurs. Symptoms may result from impingement by one or

more bony outgrowths on important vessels or nerves. The family history aids in making the diagnosis. Adequate x-ray studies permit ready diagnosis. Prolonged osseous extensions proceed outward from the bones in the direction of the muscle pull. The metaphyseal regions where these protrusions arise are widened so that the ends of the bones have a broad rectangular appearance. In the region of the osteochondromas and particularly in the small bones of the hands and feet are cartilaginous defects, visible as areas of rarefaction (Fig 286). As in single exostoses the symptoms progress until skeletal growth normally ceases, at about the age of twenty-two.

Pathologically the exostoses have the same appearance as that described for single osteochondromas. The central chondromas are identical with those described below.

The prognosis as far as life is concerned in these cases is good. After the age of twenty-two (or before if imperative), the

adults are contraindicated at this site because of the tendency of these foci to undergo malignant change following such intervention. Sarcoma may rarely supervene in these osteochondromatous growths in adults without obvious provocation.



Fig 287—Roentgenogram of a large central chondroma of congenital origin occurring in a long bone. The defect shows longitudinal streaking fraying of the cortex and calcareous stippling typical of chondroma (for typical benign enchondromas of the phalanges see previous figure).



Fig 286—Roentgenogram of multiple exostoses or hereditary deforming chondrodysplasia. The hand and forearm show the combination of exostoses, bony deformity and multiple enchondromas characteristic of this disease.

most pronounced growths which produce symptoms may be excised. The other deformities usually do not warrant an attempt at correction. If cartilaginous tissue appears within the marrow of the bone in the region of the deformity corrective procedures in

**Benign Chondroma**—Benign chondromas, chondromyxomas or enchondromas occur centrally in the small bones of the hands or feet and are occasionally seen in the spine, in the ribs or in the sternum. Other sites are exceedingly rare. Usually a phalanx of a finger in an adult is affected. Expansion and thinning of the cortex occurs with a mild degree of pain. There may be a pathologic fracture. In the roentgenogram a characteristic central translucent area is depicted. A frayed shell of bone overlies the central mass which is traversed by one or more longitudinal trabeculae (Fig 287). Small dense calcareous particles are usually visible in the tumor. When the presence of a solitary chondroma is suspected in any bone outside of the phalanges or metacarpals, roentgenograms should also be made of the hands and feet. Occasionally, these will show longitudinal areas of rarefaction with irregularities of the overlying cortex, indicating

the presence of congenital cartilaginous rests. Under the microscope lobules of adult cartilage are found at the center of the growth. Toward the periphery there are one or more strands of connective tissue accompanied by fetal cartilage or myxomatous tissue. Histologically the small chondromas situated in the carpal or tarsal bones or in the phalanges are more cellular than the larger growths found in the sternum and spine or in the shaft of the long bones (Fig 288). Nevertheless chondromas of the small bones of the hand or foot (exclusive of the os calcis and astragalus) may be cured by thorough

pathologic fracture is the first indication of the presence of the disease. Mild pain or dysfunction running a chronic course over a period of two or more years may be elicited in taking a careful history. When roentgenograms are made a central defect appears in the film surrounded by an intact and symmetrically expanded cortex (Fig 289). The cavity in the bone is traversed by irregular trabeculae of dense fibrous tissue. When a pathologic fracture is present signs of re-ossification are seen. Exploration discloses a cyst containing fluid enclosed by a wall of osseous and fibrous tissue. Under the micro-



Fig 288.—Photomicrograph taken from the margin of a benign central chondroma of a phalanx. In the upper left part of the section is adult cartilage. Below in the region of the bone shell is cellular proliferation of connective tissue. Despite the cellularity of such tissue chondroma has located. The small bones are benign and may be cured by curettage.

excision or curettage followed by cauterization with 50 per cent zinc chloride. On the other hand it is extremely dangerous to remove cartilaginous growths of the larger bones unless the entire area can be safely resected. In these larger bones the tumor will recur rapidly, will transplant in the surrounding tissues and will eventually metastasize if incompletely excised. These growths are not radiosensitive.

**Benign Bone Cyst.**—In children under fifteen years of age a benign bone cyst occurring in the upper metaphysis of the humerus, femur or tibia is one of the commonest tumors of the bone. Frequently

scope the proliferation of connective tissue and new bone formation suggests a healing reaction. Smaller cavities when present contain the remains of old hemorrhage and a sprinkling of large giant cells. Cysts with such multilocular cavities are termed poly-cystic osteitis fibrosa.

Cysts immediately adjacent to the epiphyseal line on the shaft side which have been present for less than a year show an even greater amount of vascularity and more numerous giant cells than are seen in poly-cystic osteitis fibrosa. These giant cell variants of bone cysts are to be distinguished from true giant cell tumor by their occur-

rence on the shaft side of the epiphysis in patients under twenty. The prognosis is far better than in a case of typical giant cell tumor, and the patient will respond more readily to deep x-ray therapy (Fig 289 a, b and c).

Arrest in the growth of a bone cyst without complete healing and obliteration of the cavity is accountable for the latent bone cyst seen in adults. These latent cysts are symptomless and are usually found accidentally in a routine x-ray examination.

A typical bone cyst discovered in the shaft of a long bone of a child as a result of pathologic fracture may be treated by simple splinting until reossification and healing are secured. Recurrence may take place but may follow simple curettage. If the lesion is explored the lining should be stripped, the shell of bone crushed and the cavity obliterated with bone chips. The giant cell variant of the bone cyst responds well to deep x-ray therapy in moderate dosage. Latent bone cysts in adults usually require no treatment.

Brodie's abscess, which occurs most often in the tibia of young adults producing a central defect of small size may be mistaken for a bone cyst. The cortex however is not thinned and expanded after the fashion of a cyst but instead is thickened by periosteal reaction which is accompanied by pain, tenderness and the symptoms of low grade inflammation. Benign angiomas of bone usually produce irregular multilocular cysts with thinning of the cortical area. They do not produce the symmetrical oval defect seen in cases of bone cysts. A common site for angiomas is in the vertebrae. Rarely an osteolytic sarcoma may erode the bone and suggest a cyst. Again the lesion is usually asymmetrical and a periosteal reaction so called hipping overlies the central defect.

**Diffuse Osteitis Fibrosa (von Recklinghausen's Disease)**—While the term *osteitis fibrosa* is loosely used to refer to all types of cysts of the bone there is now a tendency to restrict this term to a diffuse disease of the skeleton accompanied by adenoma or hyperfunction of the parathyroid glands. In such cases the fundamental disturbance is a super-saturation of the blood serum with calcium, increased calcium excretion and a generalized demineralization of the bones.

The blood calcium level may be elevated to from 13 to 20 mg and the phosphorus lowered to 1 or 1.5 mg per hundred cubic centimeters. In isolated areas the rarified bones show localized cyst formation and occasionally giant cell tumors. In the x-ray examination the diagnosis depends on evidences of diffuse osteoporosis, bending deformities and globular areas of cysts or tumor formation (Fig 290). Treatment is directed at a reduction of the parathyroid hormone output and recalcification of the skeleton. The para-

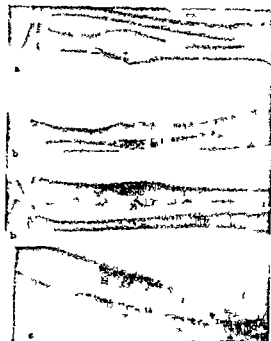


Fig 289.—Roentgen gram of a bone cyst of the shaft of the radius of a child aged six years. a The film depicts the lesion in January 1923 prior to irradiation. b The lesion in October 1924 after two courses of treatment with the x-ray (pink eleven and blue ten thousand previous hours each). c The healed lesion in August 1925 eighteen months after the last treatment.

thyroids may be explored and the adenoma surgically removed or hyperfunction may be checked by irradiation over the parathyroids. The patient should be placed on a high calcium and phosphorus diet plus vitamin D. In the diagnosis of this diffuse skeletal disease determinations of the blood calcium and phosphorus values and also of the blood phosphatase value (which is elevated), estimations of the urinary excretion of calcium and demonstration of parathormone in the blood stream by the Hamilton rabbit test are important. If proper laboratory tests

of this character are carried out, confusion of this condition with metastatic carcinoma or multiple myeloma should not occur.

long bones. In the x-ray picture the tumor produces a more or less circular defect, asymmetrical situated in the epiphysis, over-



Fig 200.—Roentgenogram of the pelvis in a case of von Recklinghausen's osteitis fibrosa cystica associated with hyperparathyroidism. Osteoporosis, bending deformity and cyst formation are characteristic of the disease.

**Giant Cell Tumor.**—Adults, usually between twenty and thirty years of age, may have a tumor of bone which produces a globular area of rarefaction in the epiphysis of

laid by a thin shell of bone, which is usually perforated at one or more points (Fig. 291 a and b). If the tumor persists without treatment for a period of more than fourteen months after the onset of symptoms, extension into the soft parts is the rule. Under a microscope many large multinucleated cells are seen embedded in a highly vascular stroma with small round and spindle cells (Fig. 292). Histogenetically, the tumor is related to the resorption of calcified cartilage by giant cells, which occurs as a step in normal growth of bone in the region of the epiphysis until late in life. Healed giant cell tumors (following irradiation) show the formation of a typical bone cyst. This and other pathologic considerations indicate that the bone cyst and giant cell tumor are closely related lesions (the two may coexist in von Recklinghausen's disease of the bones).

In the first two decades of the present century, the standard treatment for giant cell tumor was curettage followed by chemical (50 per cent zinc chloride) or thermal cauterization. Satisfactory results were obtained in about 70 per cent of cases. About a decade ago, irradiation was introduced as a method of treatment. Deep x-ray therapy administered over a period of from twelve to twenty-four months results in satisfactory re-ossifi-



Fig 291.—Early roentgenograms of a giant cell tumor in the lower end of the femur. The globular defect has a typical asymmetrical location in the epiphysis of an adult.

the lower femur, upper tibia or lower radius. There is a history of trauma, pain, swelling and pathologic fracture—the typical clinical picture of benign giant cell tumor of the

cation in some instances. Since this treatment does not afford microscopic confirmation of the diagnosis, sarcoma may masquerade under the diagnosis of giant cell tumor. Moreover, repeated courses of irradiation over a period of one or more years may result in malignant transformation with the development of osteogenic sarcoma at the tumor site. Such errors in diagnosis coupled with the long period required to achieve good results with irradiation and the occasional contractures about the joints have brought back into favor the original method of curettage advocated by Bloodgood. Recurrent giant cell tumor in the ulna, fibula or radius should be resected.

**Extraskeletal Giant Cell Tumors.**—A lesion similar pathologically to the benign giant cell tumor that occurs about deciduous teeth on the gums is known as giant cell epulis. Tumors of this type are seen in children or in young adults and are related to the normal loosening of the roots of the milk teeth by odontoclasts. Their treatment is similar to that just described for giant cell tumor, namely curettage and cauterization. Xanthomas of the tendon sheath or the synovial tissue of the joints often show numerous giant cells and are closely related to the group of tumors under discussion. Their origin is probably related to the embryonic focus in the joint or the adult site in the tendon where sesamoid bones which are derived from fibrocartilage are found.

**Ewing's Sarcoma or Endothelial Myeloma.**—Ewing's tumor is a neoplasm occurring in the first two decades of life which involves most frequently the shaft of the tibia or femur and which may ultimately metastasize to other bones. The disease never primarily involves an epiphysis. It shows the usual malignant symptoms for sarcoma of bone—pain and tumor followed by dysfunction extending over a period averaging thirteen months and may give the systemic reactions of fever and leukocytosis. In the roentgenogram the disease is first seen to widen the shaft of the bone by stimulating new bone formation in parallel layers in the endosteum and subperiosteum; the latter being raised in parallel onion peel fashion (Fig. 203 a and b). Later the tumor which arises intracortically produces areas of bone destruction in the medullary cavity and sub-

sequently in the cortex. Bone of tumor origin is not formed but fine radiating osseous spicules resembling groomed whiskers may be stimulated in the subperiosteal zone. Histologically the tumor consists of small round cells with dense nuclei resembling lymphocytes (Fig. 204) and apparently arises from the lymphatics of the haversian system.

In a case of suspected Ewing's sarcoma, deep x-ray therapy should be the first step in the treatment. Rapid shrinkage of the tumor confirms the clinical and roentgenologic diagnosis. Following the maximal effects

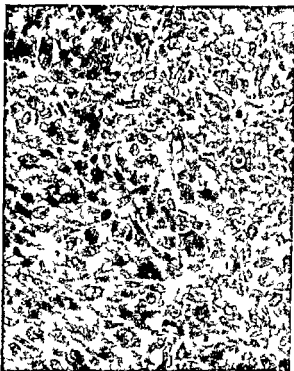


Fig. 203.—Photomicrograph of a typical giant cell tumor from the case shown in the previous figure.

achieved by irradiation either resection or amputation should be performed. When such treatment cannot be applied as in bones of the pelvis, spine or skull, subsequent courses of irradiation should be given. The same type of treatment may be used for Ewing's sarcoma of the upper femur since amputation will not effect a cure at this level. Irradiation alone rarely suffices to cure this disease. On the other hand, combined irradiation and surgical treatment have yielded slightly more than 10 per cent of five year cures.

Garre's non-suppurating osteitis affects

the shaft of the long bones in a manner closely simulating that of Ewing's sarcoma

it is rare. Rapid changes are not seen under deep x-ray therapy, hence this is the most



Fig. 993—Roentgenograms of Ewing's sarcoma in the upper portion of the humerus. *a*, January 1933, before radiation showing wing-like expansion of the cortex and peeling of the periosteum; *b*, September 1935, after deep roentgen therapy. The patient has continued to be well (1935).

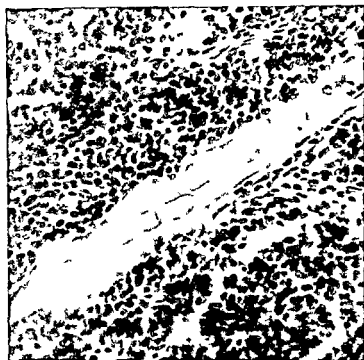


Fig. 994—Photomicrograph showing the fibrous stroma and small round cells resembling lymphocytes seen in typical Ewing's sarcoma.

In this benign condition the new bone that is produced is denser, the periosteum is not split in the characteristic onion-peel fashion and destruction of bone in the marrow cavity

reliable method of making a differential diagnosis.

In children under five years of age longitudinal streaking in several long bones with



a periosteal reaction overlying the lesion may be produced by lymphatic leukemia. In such cases the total leukocyte count may be low but the percentage of lymphocytes is usually over 80. It is well before treating a young patient with Ewing's sarcoma to have roentgenograms made of other long bones and a careful differential count made of the white blood cells. Christian's disease and syphilis of the bone may also simulate Ewing's sarcoma in the young. This makes a Wassermann reaction imperative, a rule never to be broken in the treatment of bone tumors. Christian's disease often produces large defects in the membranous bones of the skull. It may however give initial manifestations in the long bones which closely simulate Ewing's tumor. It likewise responds to irradiation. The diagnosis depends on thorough x-ray studies of the entire skeleton and on biopsy in doubtful cases. Under the microscope Christian's disease is characterized by numerous eosinophils, large macrophages simulating Dorothy Reed cell, and sometimes by foam or xanthoma cells. The predominating tissue is lymphoid in type resembling that seen in Ewing's sarcoma and congenital syphilis.

**Multiple Myeloma**—This rare and fatal condition as the name implies produces extensive involvement of the skeleton. The systemic manifestations are equally wide spread. Multiple foci of destruction are found in adults usually limited in distribution to the red bone marrow. Rheumatic pains of increasing severity, usually in the back or lower limbs, discovery of a tumor by the patient, sharp pains following exertion, fracture after injury and general weakness with anemia are the cardinal features marking the onset of the malady. As the disease progresses gradual collapse of the spine permits the lower ribs to sink to the pelvic brim giving a characteristic habitus. The patients stand with protruding abdomen, flaring ribs, shoulders braced back and feet widely apart to assist in standing. The chin is thrust forward and may sink to the chest. Involvement of the spine and ribs is accompanied by radiculitis, paraplegia and emphysema of the lungs. A nephrosis with non protein nitrogen retention and low blood pressure associated with an albuminous substance in the urine known as Bence-

Jones bodies is present in from 60 to 70 per cent of the cases. The plasma proteins may be markedly increased.

Roentgen examination of the tumors reveals areas of bone destruction which appear as multiple punched-out defects varying in size from that of a pea to that of an orange (Fig. 295). Pathologic fracture occurs in 62 per cent of the cases, a rib being most often affected. Microscopic study shows that the tumors are composed of plasma like cells each with an eccentric nucleus containing a spoke like arrangement of chromatin. There is a very scanty amount of stroma.

The average duration of life after the recognition of the disease is two years. In rare cases a patient may survive the five year period. Roentgen irradiation which al-



Fig. 295.—Roentgenogram showing the multiple punched-out areas of the skull, characteristic of multiple myeloma.

leviates the symptoms and may prolong life is the most valuable mode of therapy. The degree of anemia present determines the prognosis.

Multiple myeloma must be distinguished from metastatic carcinoma with multiple foci in the bones and osteitis fibrosa with hyperparathyroidism. The widespread occurrence of small sharply demarcated defects in the marrow cavity unaccompanied by bending deformity or the formation of new bone is the cardinal feature in the roentgenologic diagnosis of multiple myeloma. The fact that a verified case of multiple myeloma has not been reported in children is important in the differential diagnosis. Marked anemia, Bence-Jones bodies in the urine and an elevation of the plasma pro-

teins are characteristic laboratory findings which are not found in metastatic carcinoma\* or osteitis fibrosa

A solitary focus of multiple myeloma may be the only manifestation discovered by a thorough x ray examination early in the disease. More rarely patients finally die without having any other areas of bone involvement develop. Such cases of multiple myeloma with a solitary lesion must not be confused with the term solitary myeloma commonly used in England to mean benign giant cell tumor



Fig 296—Roentgenogram of a primary chondrosarcoma showing the faintly radiating calcified line and the translucent soft part showing the peripheral space which is characteristic of the disease

*Chloroma* is an exceedingly rare form of bone disease usually involving the bones about the orbit and occurring about at puberty. In this disease which has a clinical course similar to that of multiple myeloma there is a leukemic blood picture

**Primary Chondrosarcoma**—Osteogenic sarcoma containing cartilage may arise after the thirtieth year of life in a patient with benign exostosis or chondroma. Many of these malignant cartilaginous tumors how-

\* In rare instances Bence-Jones bodies have been found in cases of leukemia and of metastatic carcinoma

ever are primary in origin and occur perios-  
teally in young patients at the site where  
tendons insert directly into bone. They are  
most common in patients between the ages  
of fourteen and twenty-one years and usually  
are located on the abductor tubercle in the  
lower femur or on the tuberosity of the up-  
per tibia. The symptomatology is brief  
about six months in duration and is char-  
acterized by pain, tumor formation and dys-  
function. In the roentgenogram is seen a  
faint translucent shadow which apparently  
lifts the periosteum. This wedge-shaped  
shadow between the cortex and the elevated  
periosteum is referred to as *lifting* and is  
an important diagnostic finding (Fig 296).  
The periosteum is stripped both at the site  
of the tumor and above and below and lays  
down a few radiating spicules of calcification  
and slight amounts of new bone. Involvement  
of the cortex or the medullary cavity  
may be extremely slight in primary chondro-  
sarcoma early in the disease although  
ultimately this region of the bone is eroded.  
This is an unusually malignant form of  
tumor. It is not radiosensitive and is cured  
by amputation in only about 10 per cent of  
cases. Microscopically it is seen to be com-  
posed of cartilage which is undergoing de-  
generation accompanied by slight ossifica-  
tion and numerous strands of cellular  
precartilaginous connective tissue (Fig 297).

Osteogenic sarcoma containing cartilage  
belongs clinically to the same group as the  
extremely malignant grades of sclerosing os-  
teogenic sarcoma. In rapidly growing scleros-  
ing sarcoma small amounts of cartilage are  
found microscopically and the tumor early  
in the course of the disease may not cast a  
dense shadow on the x ray film. Such tumors  
tend to invade the marrow cavity earlier  
than the pure primary chondrosarcomas. In  
another extremely malignant grade of scleros-  
ing periosteal sarcoma the varying  
amounts of osteoid tissue are intermingled  
with a mixture of osteoblasts and pre-osse-  
ous fibrous tissue which under the micro-  
scope resemble the osteolytic forms of sar-  
coma found in the marrow cavity which  
will be discussed subsequently. By some  
authors the entire group is referred to as the  
periosteal group of osteogenic sarcoma.

**Secondary Chondrosarcoma**—This form  
of sarcoma confined to adults may super-

vene in benign exostosis, benign chondroma or multiple skeletal diseases, such as Paget's osteitis deformans or hereditary deforming chondrodysplasia. The distribution of these growths differs from that of primary chondrosarcoma in that the upper humerus, pelvis, ribs and heel are more often the regions affected. The duration of symptoms is extremely variable. There may be deformity, rheumatic pains or pre-existing tumor antedating the acute symptoms by five to twenty-five years. When a previous osteochondroma is implicated, roentgenograms show that the original lesion remains in the form of the widened metaphyseal region or as a

change. Some of these secondary sarcomas were described originally by Bloodgood as being pure myxomas of bone. They are not to be confused with benign myxochondromas of the phalanges, which do not undergo malignant change.

Secondary chondrosarcomas are cured by radical excision in approximately one fourth of the cases. The lesions are radioresistant.

**Sclerosing Osteogenic Sarcoma.**—Sclerosing osteogenic sarcoma is a malignant proliferation of ossifying connective tissue in the subperiosteal and subcortical regions of the metaphysis, often at puberty. The lower femur and upper tibia are the most common

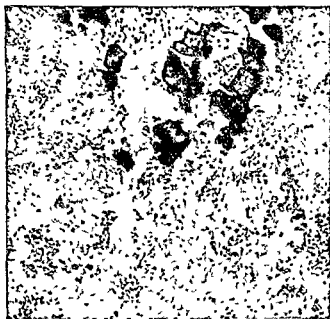


Fig. 297.—Photomicrograph showing clusters of small spindle cells (precartilaginous connective tissue), fetal cartilage cells and irregular calcification in a hyaline matrix typical of primary chondrosarcoma.

protruding ossified base or pedicle. Above there will be a granular infiltrating periosteal shadow, eroding the benign lesion from above downward. In advanced cases the entire tumor site is the seat of an infiltrating mass with scattered osseous debris which penetrates the marrow cavity and leads to pathologic fracture. The secondary nature of the growth is easy to establish when the skeleton is diffusely involved by a pre-existing benign condition such as multiple exostoses or Paget's osteitis deformans.

Histologically, there are cartilaginous masses interspersed with calcified and osseous material and large amounts of connective tissue with evidence of myxomatous

sites. The disease runs a fairly acute course with pain, tumor and dysfunction, perhaps preceded by trauma. The average duration of symptoms is ten months. In the roentgenogram the dense spicules of new bone radiating out in a sun-ray fashion are a characteristic feature (Fig. 298). Immediately beneath this, the bone substance is sclerosed by the infiltration of tumor tissue. In some early cases of sclerosing sarcoma, increased density in the marrow cavity is the first evidence of the disease in the roentgenograms.

The neoplasm is an exaggeration of the function of osteogenesis; hence the gross specimens show osteoid substance and bone often of extreme density stripping the peri-

osteum, extending into the soft parts, penetrating the cortex and invading the marrow cavity. Microscopically, a proliferation of malignant osteoblasts is seen dispersed in a disorderly fashion among immature islands of osteoid tissue. Irregular bone spicules are outstanding. Here and there a small island of cartilaginous tissue recalls the fact that the periosteum from which the growth arises has differentiated from pre-existing perichondrium.

pable mass within six weeks following injury. The ossified tumor shows a wedge of bone that is laminated and separated from the shaft by an interval of soft parts. The marrow cavity and cortex are undisturbed. In sarcoma of bone, all the various zones are affected, including the soft parts, periosteum, cortex and marrow cavity. Acute osteomyelitis may give indications of a previous skin infection. The symptoms are present for a number of days rather than weeks, as in sar-

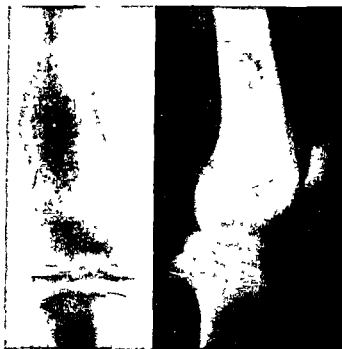


Fig 298

Fig 299

Fig 298—Roentgenogram of typical sclerosing sarcoma of bone occurring in a boy of fifteen who had had symptoms of pain and swelling for six weeks.

Fig 299—Roentgenogram of a chondroblastic sarcoma arising at the epiphyseal line and invading the shaft of the femur in a boy of sixteen years. There is a definite periosteal reaction. The lesion was curetted twice, and finally the leg was amputated. The patient died of pulmonary metastases six months after the first curettement.

Sclerosing sarcoma is radioresistant. Permanent cures are obtained in approximately one fourth of the cases in which prompt resection or amputation is performed.

The periosteal sarcomas of bone, including chondro-sarcoma and sclerosing sarcoma, must be differentiated from osteomyelitis and myositis ossificans. In these rapidly growing neoplasms there may be pre-existing trauma, as in myositis ossificans, and a mild degree of fever and leukocytosis suggesting osteomyelitis. The most important diagnostic aid is the roentgenogram. Traumatic myositis ossificans usually forms a hard pal-

coma. A leukocyte count of over 15,000 favors osteomyelitis. Fluctuant areas probably contain pus and should be aspirated. Garre's non-suppurating osteomyelitis usually involves the shaft and extends half the length of the bone. In this benign condition, radiating spicules are rarely seen in the roentgenogram. In tuberculosis the neighboring joint is usually involved, but this is an exceedingly rare complication in cases of sarcoma of bone.

**Chondroblastic Sarcoma.**—This type of tumor was first described as a separate variety of sarcoma of bone by the writer in

1930 It is a form of osteolytic sarcoma which is frequently confused with giant cell tumor and referred to in some instances as a malignant variant of giant cell tumor. At the present writing the permanent cures obtained by roentgen irradiation and by curettage in cases of chondroblastic sarcoma and the proliferation of giant cells seen histologically have led other authors to return this new growth under the classification of giant cell tumor. Codman refers to it as an epiphyseal cartilaginous giant cell tumor and doubts that it is malignant. Nevertheless in the roentgenogram this tumor usually simulates sarcoma and in the writer's series some of the patients who have been well studied and carefully followed have died with metastases. This outcome is not seen in cases of typical benign giant cell tumors. Chondroblastic sarcoma is the one form of osteogenic sarcoma about which important differences of opinion still exist.

There is general agreement however that this is a tumor of the epiphyseal line in which the cartilaginous elements of the growth disks are involved during puberty. The epiphyseal lines of the upper tibia, lower femur, upper humerus and lower radius are the common sites. In the x-ray picture there is seen bone destruction with or without an expanded bone shell surmounted by definite periosteal reaction (Fig. 299). The tumor grows rapidly and fluid may be observed in the neighboring joint. At exploration the growth is found to extend into the soft parts surmounted by a layer of periosteum or it is found within a shell of bone. The major portion of the neoplasm invades the cancellous substance. The tissue is vascular but may show gray or bluish areas of cartilage. The characteristic microscopic features are remnants of hyaline cartilage (with or without calcification) intermingled with characteristic giant cells. Large chondroblasts which have a vesicular nucleus and a fair amount of cytoplasm are present in the stroma. The controversy hinges on the interpretation of the cartilaginous elements. Do these cells represent normal growth of the epiphyseal cartilage which at puberty is secondarily invaded by giant cell tumor tissue or are they a true neoplastic proliferation? In the writer's series of about twenty-five cases there are three patients who are

still living and have not undergone amputation. One of these patients was treated by means of curettage, radium implantation, Coley's toxins and roentgen rays more than twenty years ago and is still alive. In a fairly recent case a biopsy was performed and then deep x-ray therapy was administered and the patient has remained well for approximately ten years. Another patient was curetted and was reported five years later to be living and well. Fourteen patients in the series are known to have died of this disease. At present roentgen irradiation followed by resection is advised for other than weight



Fig. 300.—Platomicrograph of a chondroblastic sarcoma showing the remains of calcified cartilage and typical large chondroblasts. Elsewhere in the tumor were many mult-nucleated giant cells. The lesion was explored in 1930 and received thereafter deep x-ray therapy. The patient was reported well in 1934.

bearing bones. The writer would still advise amputation for such a lesion in the tibia or femur despite the fact that the case illustrated in figure 300 has been controlled by deep x-ray. The condition can be suspected but not adequately diagnosed without a biopsy.

**Osteolytic Sarcoma.**—Osteolytic sarcoma is a destructive tumor which arises in the marrow cavity near the end or in the mid-shaft region of a long bone. The age distribution of these patients is variable. The majority are young adults but some are of advanced age. The lesion shows an unusual

tendency to undergo pathologic fracture. In the roentgenogram a rapidly extending area of bone destruction is seen which dissolves the cortex without expansion and involves the periosteum and overlying soft parts (Fig. 301). The tumor appears grossly to be ex-



Fig 301—Roentgenogram of osteolytic sarcoma showing an asymmetrical area of bone erosion and periosteal reaction overlying the tumor

tremely vascular and hemorrhagic, and its tendency to bleed excessively at exploration led to the caption by early authors of "malignant bone aneurysm." The disease is characterized microscopically by large malignant spindle cells and osteoblasts with numerous mitotic figures. There is little tendency to ossify, and in all probability the tumor represents a more malignant grade of osteogenic sarcoma, similar to or identical in its origin with that of sclerosing osteogenic sarcoma. Numerous giant cells may be present in the lesion, making it difficult to distinguish it at biopsy from a giant cell tumor. In elderly adults amputation affords the best chance of cure. In young adults roentgen irradiation will control the lesion sometimes for several years but will not cure the disease. On the other hand, cures by radical operation are obtained in less than 5 per cent, so that the more conservative treatment may be preferred to the loss of the limb in younger patients.

It is well to emphasize the fact that no didactic statements can be made in regard to the mode of therapy to be adopted in young persons for either chondroblastic or osteolytic sarcomas of bone. The treatment of choice will ultimately rest on the degree of success which is achieved by the newer methods of deep x-ray therapy.

**Metastatic Carcinoma.**—A large group of bone tumors are metastatic in origin. The most frequent cancers which give rise to such lesions are those of the prostate, breast, kidney, thyroid and lung. Metastatic cancers of the breast or prostate, which far outnumber the other forms in this group, usually produce multiple involvement of the pelvis, spine and skull. Mammary cancer with secondary deposits in the bone shows in the x-ray picture multiple foci of mottling due to a combination of bone formation and bone destruction (Fig. 302). With metastases from carcinoma of the prostate, there is a similar skeletal distribution of the lesions, but in this condition bone formation predominates with obliteration of the normal



Fig 302.—Roentgenogram showing areas of increased bone density and rarefaction produced by metastatic carcinoma of the skull. The entire skeleton, with the exception of the hands and feet, legs and forearms was similarly affected

bone markings. Carcinomas of the prostate and breast with bone involvement are best treated by means of deep x-ray therapy, which relieves pain and prolongs life. The improvement of symptoms observed with this form of treatment aids in establishing

the diagnosis. The daily oral administration of from 10 to 15 Gm of calcium gluconate over a long period of time may be extremely helpful. Pain may be diminished and calcification may take place.

The forms of metastatic carcinoma just discussed must be distinguished from Paget's osteitis deformans which is characterized by enlargement of the skull and increased density of the bones of the spine and pelvis. The skull has a characteristic nigger wool appearance and there is bowing of the tibiae with a wavy deformity in the cortical area sometimes accompanied by cyst formation but the striations of the bone are usually preserved. Metastatic carcinoma obliterates these striae; it usually does not metastasize below the knees and does not give rise to the characteristic bowing of the tibiae. In Paget's osteitis the blood level of alkaline

this is seen in the roentgenogram where the shadow in the soft part exceeds that in the bone. Osseous destruction proceeds from without inwardly and there is often no evidence of periosteal reaction. The microscope reveals a fascial sarcoma or a fibrosarcoma with numerous spindle cells and various amounts of collagen. The lesions are not radiosensitive and are often of a very low degree of malignancy. They tend to recur after local removal but five year cures have been established by ultimate amputation after two or three such recurrences.

Another form of tumor formerly classed as a periosteal fibrosarcoma invades the bone from without in a manner similar to that in case of fascial sarcoma. This is sarcoma of the nerve sheath and usually arises from the deep peripheral nerves. The writer knows of no case of sarcoma of the nerve

FIVE YEAR SURVIVALS IN MALIGNANT PRIMARY TUMORS OF BONE

No. of Cases	Form of Malignant Tumor	Five Year Survivals	
		No. of Cases	Percentage
158	Sclerosing osteogenic sarcoma	90	18
191	Osteolytic osteogenic sarcoma	11	9
239	Chondrosarcoma (primary and secondary)	38	16
26	Chondroblast sarcoma	6	23
115	Fibrosarcoma	13	11
44	Fibrosarcoma	17	39
40	Multiple myeloma	1	0
253	All forms of primary malignant tumors	106	14

phosphatase is usually markedly elevated. In metastatic carcinoma from the prostate the acid phosphatase level is elevated.

A solitary focus of destruction in a single bone is often produced by metastatic tumors of the kidney. The lesion in such cases is usually in a long bone (upper humerus or upper femur) at the site of nutrient vessels. Bone is destroyed without evidence of regeneration. Cancer of the thyroid, stomach and lung, metastatic melanoma and malignant lesions of the bladder may give rise to similar metastases.

**Fascial and Neurogenic Sarcoma Invading Bone**—So-called periosteal or parosteal fibrosarcoma is defined by the Bone Registry of the American College of Surgeons as a fibrous tumor arising in the outermost layer of the periosteum. These sarcomas however more often arise in the soft parts and invade the bone by direct extension. Evidence of

sheath with invasion of bone in which the patient has survived the five year period regardless of the form of treatment. Thus while the term spindle cell sarcoma may be used to refer loosely to the most frequent forms of sarcoma which invade the bone from without it is important clinically to distinguish the fascial from the neurogenic type.

Disturbances of the vessel and nerves and diffuse lipomatosis in a single extremity may also produce general rarefaction and deformity of the bone.

In rare instances other forms of sarcoma overlying the bone may show evidence in the roentgenogram of a large osseous defect. Wilms' embryoma of the kidney in children, malignant sacrococcygeal neoplasm, liposarcoma and myosarcoma all may produce such secondary bone lesions. In these malignant conditions while the prognosis depends

on the primary lesion, involvement of the bone is a serious complication and makes the outlook following any form of treatment highly unfavorable.

Early recognition and prompt radical therapy have increased the five year survivals among patients with malignant tumors of the bone. Among patients with sarcoma, those surviving the five year period are usually permanently cured, but this is not true of those with metastatic carcinoma or multiple myeloma. The accompanying table indicates that approximately 14 per cent of the patients with malignant tumors of the bone survive the five year period.

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## XVII. FRACTURES

### GENERAL DISCUSSION

A fracture is the breaking of a bone or cartilage usually as a result of external violence

**Varieties**—A *simple fracture* is one in which there is no communication between the bone at the site of fracture and the outside air. Usually this means that there is no overlying wound of skin or mucous membrane. A *compound fracture* is one in which there is a communication between the site of fracture and the outside air through an opening in the skin or mucous membrane. This may have been caused either from within or from without. It is possible for an overlying wound not to communicate with the fracture, this then being a simple fracture although it is preferable for purposes of treatment to consider it compound. If an open operation is performed on a simple fracture a compound fracture is produced. If the unbroken skin and soft parts slough away in a simple fracture a compound fracture may be produced.

**Fractures may be incomplete or complete.** An *incomplete fracture* is one in which the continuity of the bone is only partially divided. There are several varieties. A *fissure fracture* is one in which there is a crack partially through the bone. This may be either transverse or longitudinal. A *depressed fracture* may involve only the outer table of the skull not passing completely through the bone. A bullet wound may create a *puncture fracture* without a break across the bone. A *greenstick fracture* is one which has occurred from marked bending so that the bone is splintered on the convex side but remains intact on the concave side like a splintered branch of a green tree.

A *complete fracture* is one in which the entire continuity of the bone is divided. The fracture line if single may be transverse, oblique, spiral or even longitudinal and often there is more than one line of fracture. A *comminuted fracture* is one in which there are two or more lines of fracture which divide the bone into more than two fragments.

At a joint this may be a combination of a transverse and longitudinal fracture producing a T fracture or a combination of two oblique fractures producing a Y fracture. An *impacted fracture* is one in which with or without lateral displacement the firmer cortical bone is telescoped into the softer cancellous bone. This occurs particularly at the neck of the humerus and of the femur. A *compression fracture* is one in which two opposite surfaces of the bone are driven closer together than normal. This usually is noted in cancellous bone with considerable fine comminution often resulting in a definite diminution in the area of bone shown in the x-ray picture as in fractures of the vertebrae. A *sprain fracture* is a sprain in which a small fragment of one of the bones has been pulled off usually at the site of a ligamentous attachment. A *spontaneous fracture* is one which occurs without apparent competent exciting cause. Strictly it is not spontaneous as the break is necessarily caused by trauma even though this is slight. It is usually found in patients with bone atrophy, osteogenesis imperfecta or general conditions affecting bone. A *pathologic fracture* is one which occurs without apparent competent exciting cause at the site of local disease of the bone.

Displacements of the fragments may be lateral, angular, longitudinal and rotary or a combination of these types. The displacements interfere with the proper axis of an extremity. A posterior angulation produces what is known as dishing. A longitudinal displacement may produce shortening of an extremity called over riding or it may result in separation of the fragments as seen in fractures of the patella or olecranon or in overpull in the use of traction.

A fracture is described as being located either in the shaft or in the extremities. At the ends of the bones there is a further designation according to the anatomical part broken e.g. surgical neck, tuberosity, condyle, head or articular fracture or epiphyseal separation. An articular fracture is one

in which the fracture line runs across the attachment of the joint capsule. An intra-articular fracture lies entirely within the joint. An epiphyseal separation is a fracture which passes wholly or in part through the epiphyseal line. It is often unrecognized and is of great importance because bony union of the epiphysis may result with arrest of growth. A subperiosteal fracture is a complete fracture without displacement in which it is believed that the periosteum has not been torn. Multiple fractures may be at different levels in the same bone or in different bones. The term *complicated fracture* is sometimes used when recovery will be complicated because of damage to artery, nerve or joint.

**Etiology**—*The Predisposing or Indirect Causes*—Age.—Fractures particularly of the clavicle, elbow and forearm are common between the ages of two and four years on account of unsteady gait and frequent falls. Between the ages of four and six years many greenstick fractures occur as the bones are soft. Between six and twelve if a fracture occurs near a joint there is liable to be epiphyseal separation. The incidence of fractures increases from six years on reaching its maximum between the ages of thirty and forty, that is it coincides with the age of greatest activity. On account of bone atrophy fractures of the neck of the humerus and of the neck of the femur are particularly common in old age.

**Sex**—The incidence is about the same in boys and girls up to four or five years of age, after which fractures occur more commonly in males up to forty-five. This is undoubtedly a result of their more active life and more hazardous trades. Some authorities state that fractures are from seven to ten times more frequent among males than among females during this period. After forty-five the number is nearly equal in the sexes with a slight preponderance among females in advanced age.

Bone atrophy is a predisposing cause of fracture as noted in old age from prolonged lack of use as in cases of paralysis or in kylosed joints and in general paresis, tabes and syringomyelia. Osteogenesis imperfecta or idiopathic fragilitas ossium is an inherited tendency to spontaneous fracture. Generalized bone conditions such as rickets and

osteomalacia and localized bone disease such as sarcoma, metastatic carcinoma, destruction of bone in acute osteomyelitis and bone cysts are favorable to the occurrence of fracture.

**Exciting or Direct Causes**—There are three exciting causes—direct violence, indirect violence and muscular action.

A fracture by *direct violence* is one in which the bone is broken immediately below the point of impact. Injury to the soft parts always accompanies the fracture which is frequently compound. The line of fracture usually is transverse or slightly oblique and is often comminuted. The common example at the present day is in a patient who has been run over by the wheel of an automobile.

A fracture by *indirect violence* is one in which compression or bending is exerted at a distance so that a bone gives way at its weakest point. A typical example of the compression action of indirect violence is seen in a fall from a height in which the person lands on his heels. According to the position of the skeleton in landing he may sustain comminuted fracture of the os calcis, fracture of the lower extremity of the tibia often with fissures running longitudinally, fracture of the shaft of both bones of the leg, compression fracture of one or more vertebrae or fracture of the base of the skull. Similarly a fall on the extended palm may result in a fracture of the lower extremity of the radius, the head of the radius, the lower extremity of the humerus, the surgical neck of the humerus or the clavicle. The site of the fracture varies both with the exact position of the skeleton at the moment of impact and with the age of the patient. The bending action of indirect violence is well seen in fractures sustained in turning the ankle in which the weak point of the fibula immediately proximal to the external malleolus is the frequent site of fracture. If at the same time that the bending action occurs there is a certain amount of rotation of the body on the foot the fracture is often spiral rather than simply oblique. Fractures caused by indirect violence are somewhat less likely to be comminuted. If compound they are usually compounded from the inside by a fragment of bone which pierces the skin. The injuries of the soft parts are

those caused by the sharp ends of the fractured bone. Fractures by indirect violence occur much more commonly than those by direct violence.

Fractures by muscular action are less common the most frequent examples being fractures of the olecranon and patella. A sudden contraction of the triceps or the quadriceps usually because of an unexpected movement fractures these bones transversely. More rarely a long bone is fractured by muscular action e. g. the shaft of the humerus when the person is throwing a baseball or the shaft of the femur when a patient with talipes merely rolls over in bed. The mechanism of fracture may be due in an individual patient to a combination of any two or all three of the direct causes.

The comparative frequency of fractures in various bones is difficult to determine. Many series of such statistics have been published including thousands of cases but they are usually in entire disagreement as to the order of frequency. This is easy to understand. The usual site of the fractures seen in hospital wards is different from that seen in the dispensaries, a hospital in a residential district sees fractures that are usually in other locations than those seen in an industrial or congested district, a hospital with an ambulance service may see more lower extremity and skull fractures while a hospital without an ambulance may see more upper extremity fractures because the patients are ambulatory. All of the factors obviously account for the statistical variations.

There are probably more fractures of the upper than of the lower extremity. Fractures of the phalanges and ribs are probably most numerous. Following these without attempting to place them in order of frequency the common fractures are of the lower extremity of the radius the region of the ankle the metacarpals the shafts of the bones of the leg the skull the clavicle and the humerus.

**First Aid and Transportation.**—Except on hospital ambulances first aid after fractures is more likely to be rendered by laymen than physicians. In many instances this is the critical part of the whole treatment. It is necessary to know the principles of first aid for use while serving as ambulance surgeon but it is of even greater importance

to be able to guide and instruct the general public. Splint them where they lie is properly the first principle in fracture treatment but if it is lived up to it is obvious that the splinting will rarely be done by a physician. Splinting must be considered as only a means of aiding transportation not a part of the definite treatment of the fracture. The physician must be prepared to instruct the public on the most effective manner of transporting a patient with a fracture to the physician's office or to a hospital. In general those trained by the Red Cross, Boy Scouts, etc. know more about first aid than most physicians because little responsibility has been accepted by the physician until the injured person arrives at the office or hospital.

To quote from *An Outline of the Treatment of Fractures* issued by the American College of Surgeons:

*The injuries resulting from fractures are not limited to those occurring at the time of the accident. Unskillful attempts to use the injured extremity may cause or increase displacement of fragments, increase the lacerations of soft parts and perhaps fail to penetrate of the skin by the ends of the bone. Secondary infection is often due to the awkward efforts of the bystander. A man is struck by an automobile, thus breaking his leg. Except for the broken bone without displacement the original injury may be merely a slight peroneal tear and a mild contusion of the soft parts, but he is helped to his feet and the leg gives way and the fragments slide over each other, thus stripping off the periosteum and tearing the muscles. He falls to the ground only to be picked up and carried to the sickle with the leg hanging. Larger blood vessels are torn and the end of the bone comes through the flesh, perhaps the skin and even the tibia. He is lifted to rest with a coat bandage and surrounded by people anxious to help. Someone sees that his leg is crooked and straightens it out. The exposed end of the bone re-enters the wound, a bit of trouser and the dirt of the street. He is lifted and carried to a car or ambulance. The time someone carries the injured leg, the latter intentions that coarctation and the ends of the bone are cleaned and buried in the bed of lacerated tissues and the contaminating organisms are well disseminated throughout the area. Dr. G. L. S. ride and in the transfer to the accident ward or the doctor's office unless he has been carefully splinted there is more jolting and more damage. We all that his troubles were over it too often the sad story continues. Lack of efficient protection as he is lifted to and from the x-ray table and as he is being anesthetized increases his still more injury.*

Compare this exaggerated picture with a similarly injured man who is allowed to remain where he is until a proper splint can be applied or at least until he can have someone pull him on his foot as he is being lifted

and carried whose examination is thoroughly but gently carried out and whose treatment is instituted with but little additional injury. The difference in these two cases as regards period of disability and amount of permanent functional disturbance is great.

Principles of first aid (1) If suspicious that a fracture is present render care as for a fracture (2) combat any existing shock (3) avoid every unnecessary manipulation (4) protect any existing wound by the best means available (5) splint effectively before transporting the patient wherever found and (6) transport carefully.

The injured person should first be examined rapidly in order to attempt to determine whether he is seriously hurt. The clothing usually does not need to be removed. In examining a patient try to keep all parts thoroughly covered except the part which is actually being examined at the moment. One should depend on pain, loss of function or deformity for the emergency diagnosis of fracture and should rarely if ever try to obtain crepitus or false point of motion. If the patient thinks that he felt a bone snap for emergency purposes one should be satisfied with his history and not attempt to prove the diagnosis on the street. If suspicious that a fracture is present always treat the patient as if the diagnosis of fracture had been confirmed.

The saving of life comes first and the saving of limb second. If the patient is in shock this demands treatment before anything is done for the fracture. There is no use in *splinting a limb carefully while neglecting to treat shock from which the patient may be dying.* On the other hand traction on an extremity may be the most effective means of combating shock. If morphine is available this is the first and best treatment for shock. It allays pain and thereby quiets the patient's restlessness. The body heat must be maintained by sufficient extra covering.

If a wound is present which possibly connects with a fracture it should not be washed out. A sterile compress should be placed over the wound preferably without the previous application of any antiseptic. Bleeding should be stopped. It is rare that this cannot be done with a firm compression bandage. Tourniquets should not be used until compression has proved of no avail.

Deaths have been caused by an improperly applied tourniquet which allowed some arterial blood to enter the part and only shut off the venous return. It is common to see all bleeding stop as soon as a tourniquet is removed. If a tourniquet must be used it should be loosened every half hour to allow blood to return to the part distal to the tourniquet.

Do not attempt to replace the fragments in a compound fracture with projecting bone. If the bone disappears beneath the skin in the course of the application of traction this should not cause anxiety. The patient must be operated on in any case to clean up the wound. It is important that word shall accompany the patient that the bone has been exposed in order to guide the treatment by the next physician.

If materials are not available to splint the fracture properly the patient should not be lifted into the first automobile and rushed to a doctor's office or hospital. It is far better to cover the patient adequately and let him lie on the ground where he was found until he can be splinted and moved in an ambulance. If it is necessary to change his position at all before splinting in the instance of an extremity fracture pull should be exerted on the injured part while he is being moved.

*Special Indications in Individual Fractures*—**SKULL**—Keep the patient in the recumbent position. A pillow may be placed under his head. It is better not to use morphine; *the cerebral centers may be already depressed by the injury* and this depression should not be added to by the use of morphine. If for any reason it is believed that morphine is necessary it should be accompanied by caffeine. Any patient with a history of even momentary unconsciousness should be confined to bed and kept under observation. The symptoms of serious injury may not appear until a number of hours after the accident. In general the skull injury is of little importance but the possibility of laceration of the brain demands attention.

**LOWER JAW**—Try to bring the lower teeth against the upper teeth gently. Apply the center of a narrow bandage under the chin. Pass one end over the top of the head and cross the two ends above one ear tying them

tightly at the base of the skull the crossing being on the side injured. Do not use a four tailed bandage.

**CLAVICLE AND SCAPULA**—Use a sling to support the upper extremity with the elbow flexed and a body bandage to diminish movement at the shoulder.

**SPINE**—If the mechanism of injury is such that a fracture of the spine may have been produced transport the patient as though a fracture had occurred even though no objective signs are discovered in a cursory examination. Death or permanent disability results more commonly from improper transportation of the patient with a fracture of the spine sometimes unrecognized than from any other injury. If the injured person complains of pain in his back it may be broken. If he complains of pain in his neck he may have a broken neck. Do not lift an injured person or his head until he has told you whether he can move his legs or fingers. If he cannot move his legs his back is broken. If he cannot move his fingers his neck may be broken. In either instance the spinal cord is injured. If the patient's body is bent while he is being carried in the former instance or if his head is lifted so as to give him a drink in the latter instance the injured spinal cord is inevitably ground between parts of the broken spine thereby destroying any useful remnant of the cord which may have escaped injury. Do not allow the injured person to sit up. If a fracture of the spine may be present and the victim is unconscious handle him as though his neck were broken.

For the patient with possible fracture of the dorsal or of the lumbar region the underlying principle of hyperextension should be observed in any moving and in transferring him from the site of accident. He should be carried face downward on a rigid support. Wherever found the patient should be slowly and evenly rolled over so that he rests on his abdomen on this rigid support. One of his forearms should be placed under his head which is turned to the side as in the Schäfer resuscitation method. Whenever the patient must be moved at all before the rigid support is obtained he may be rolled onto his abdomen on a sheet or blanket. This sheet may then be lifted by two per-

sons one at each end and the patient carried prone in this improvised hammock.

In case of possible fracture of the cervical vertebrae gently slide the patient sidewise onto a rigid support so that he rests face upward with the arms at the side. Never tilt the head forward. No pillow should be placed under the head or neck. Pillows or sand bags may be placed each side of the head to prevent rotation.

**PRIVIS**—The injured person should be transported on a rigid support lying on the back. If the injury seems severe the thighs as well as the legs should be tied together. The position of the thighs and legs should be that naturally assumed. If enough assistance and the necessary material are at hand a body swathe may be placed about the pelvic girdle. This should be applied snugly but not tightly.

**EXTREMITIES**—The only effective and advisable method for transporting a patient with a fracture of the long bones of either upper or lower extremity is by some form of fixed traction. This requires the use of a splint of the Thomas type. By fixed traction is meant that pull is exerted from fixed points above and below so that the traction remains the same whatever the position of the limb or splint. Over riding is characteristic of these fractures and there can be no generally effective immobilization without traction. In addition traction relieves pain and shock and prevents further damage during transportation. The fixed traction splint should be applied if there is any possibility of fracture between the hip joint and the foot or between the shoulder joint and the middle of the forearm no matter whether the injuries are simple or compound.

The full ring Thomas splint can be used on either upper or lower extremity. More generally applicable and advisable splints of the Thomas type are the Murray-Jones hinged arm splint for the upper extremity and the Keller-Blake hinged half ring splint for the lower extremity. These splints should be applied wherever the patient is found without changing his position.

**General Requirements of Application**—There are certain standards that are necessary in the application of this general method. It does not make any difference what particular procedure is used so long as

one appreciates what must be accomplished. In the use of traction there are six requirements: 1. There must be some adequate form of hitch and it is necessary to protect the part beneath the hitch so that it will not be injured. 2. The traction hitch should be applied above the ankle or the wrist. 3. There must be some means of increasing traction by twisting so that the desired pull is obtained. 4. The extremity being in traction must be supported. One must not depend merely on traction for the entire support of the limb. 5. Not only must the extremity be supported from below but lateral movement must be prevented. 6. In a case of

traction is being made the whole limb is slowly lifted several inches from the ground. The half ring splint is slipped from the outer side beneath the extremity. The side bars of the splint are placed in the median horizontal plane of the thigh so that the ring rests against the tuber ischi. The strap is buckled over the anterior surface of the thigh. The lower end of the splint rests against the body of the assistant who is still applying traction. The ankle region is protected by cotton wadding or the shoe. A traction hitch is applied (an army traction strap or muslin bandage about the ankle or adhesive plaster to the leg). The traction hitch is fastened



Fig. 303—Lower extremity in a Keller-Blake long half ring splint with fixed traction applied according to the Beckman Hospital method.

fracture of a lower extremity the whole splint must be suspended so that the heel will not at any moment rest on the ground, the floor of the ambulance or elsewhere.

**EXAMPLE OF TYPICAL APPLICATION.**—Take for example a case of possible fracture of the shaft of the femur (Fig. 303). The patient is covered with blankets. Morphine is administered if available under medical supervision. The foot with or without the shoe on is grasped firmly by an assistant with both hands placed laterally. Gentle steady firm traction is made in the axis of the extremity. Manual traction is maintained until splint traction is established. While

to the end of the splint and traction is increased by a Spanish windlass action with a tongue depressor and adhesive plaster or a long nail. The manual traction is then released. The extremity is supported in the splint by means of muslin hammocks and clips applied before the splint is put on or by a wide cotton bandage wrapped from below upward about the extremity and traction bars after traction is applied. Lateral movement is prevented by turns of muslin bandage tied above and below the knee in the former instance. The end of the splint is suspended to the stretcher bar or to the roof of the ambulance. A foot piece is advisable

if transportation is to be prolonged. The method of applying traction to the arm is quite similar (Fig. 304).

In hospital practice a traction splint should be applied immediately in the emergency room, if it has not been done before. The patient is transported to the x-ray room and to the ward with traction on. The removal of the patient's clothes is supervised so that if traction must be loosened, it is maintained manually until it can be reapplied. The traction splint is kept on until the patient is in the operating room and under an anesthetic.

were applied from the axilla to beyond the foot for fractures of the hip and thigh, but these are difficult to apply and probably do more harm than good. It is preferable simply to bind the thighs and legs together using the uninjured leg as a splint. [The editor considers that the long, side ("Liston") splint is preferable.]

For a fracture of the patella, leg or ankle a pillow which is drawn firmly around the part in its proper relation is fairly satisfactory. A padded posterior wooden splint will suffice for patellar fractures and two lateral wooden splints extending from mid-thigh to

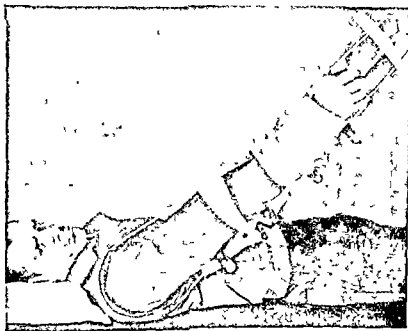


Fig 304—Upper extremity in Murray-Jones hinged arm splint with traction fixation applied according to the Beekman Hospital method

If a Thomas splint is not available, the first aid treatment of a fracture of the humerus should consist of binding the arm to the side of the body, with or without a pad in the axilla and with or without a padded wooden splint on the outer aspect of the arm, the wrist being supported by a narrow sling passed about the neck.

For fractures of the elbow, forearm, wrist or hand, padded splints of wood or heavy cardboard will suffice for transportation.

If a Thomas splint is not available for a fracture of the lower extremity, it must be appreciated that unless manual traction is exerted during transportation there is always danger of increasing the extent of the injury. Formerly, long, side wooden splints

foot may be used for leg and ankle fractures. For all fractures of the foot, any splint of firm material which keeps the heel and toes from touching any object will suffice.

It is important to remember that the type of first aid and transportation is a large factor in the ultimate recovery. It has been stated that in World War I the mortality of gunshot wounds of the femur was reduced from 80 to 20 per cent by the routine use of the Thomas splint. Physicians need to be cooperative in urging the public to carry out these methods of transportation and not insisting, as do some, that a fracture should not be touched until the patient reaches the doctor's office or the hospital.

**Anesthesia.**—Whenever any change in

position or manipulation of fragments is indicated an anesthetic should be used this assures relaxation of muscles and allows the surgeon to be free to do whatever he finds necessary. Because one believes that a reduction will be easy this does not justify failure to use an anesthetic. Even if it is possible to obtain a perfect reduction without its aid more damage to soft parts is liable to occur as a result of the resistance of unrelaxed muscles. The patient's statement that he can stand the pain is not of importance as the anesthetic is not given for this reason but to relax the muscles and allow a perfect replacement of fragments as possible.

Local anesthesia is the best in the form of an injection of novocain directly into the hematoma around the ends of the fractured bones. From 10 to 30 cc of a 1 per cent solution is sufficient. The site of the needle puncture is prepared by the application of tincture of iodine. The needle is inserted at a point close to the fracture site the plunger is withdrawn slightly until blood appears in the syringe the novocain is then injected. Relaxation is usually obtained within from two to five minutes. Unless the injection is into the hematoma as proved by blood in the syringe it is rarely successful. It is a simple procedure no extra anesthesiologist is required there is no struggle and consequently no danger of further displacement of the fragments either while the anesthesia is being induced or during recovery. Furthermore the patient can cooperate in the application of splints for example by sitting up for the application of a shoulder splint. Twenty-four hours after a fracture is sustained the blood is frequently coagulated diffusion of the anesthetic does not occur and no relaxation results. During the first twenty-four hours the anesthetic is quite uniformly successful. The only other contraindication is the occasional damage to a large vessel or nerve by the needle. Its use is indicated in all simple fractures of an extremity. If more than one bone is broken injection will be required at each fracture site. The relaxation usually lasts from one half to three quarters of an hour and gives sufficient time for the physician to reduce the fracture apply splints take a roentgenogram and if the position is not absolutely

satisfactory attempt reduction again without further injection of the anesthetic. Meantime the patient is awake and cooperative. Local anesthesia can rarely be used in children.

Two other forms of local anesthesia are used nerve block and regional anesthesia. Nerve block or plexus block requires considerable skill and practice. Brachial plexus block is excellent in cases of fracture of the humerus. Regional anesthesia does not demand special skill but does require a considerable amount of anesthetic. Both of these forms may be used in compound fractures. Regional anesthesia is excellent in fractures of the skull.

General anesthesia has been used in cases of fracture for a great many years. Ether is preferred for a long procedure. Nitrous oxide cyclopropane or ethylene with oxygen is suitable for short procedures. Ether gives more complete relaxation. All require the presence of a skilled anesthetist. In the use of a fluoroscope in connection with reduction there is some danger of ignition of the ether vapor or of ethylene unless a spark proof unit is used. Gas-oxygen is less dangerous from this point of view but its administration is difficult in a dark room. Rectal avertin is a valuable basal anesthetic.

Spinal anesthesia is excellent in cases of fractures of the lower extremities. From 80 to 100 mg of novocain injected beneath the dura in the fourth lumbar interspace will usually give complete relaxation for an hour. Accidents are rare when this amount is used. The crystals are dissolved in about 2 cc of spinal fluid.

Intravenous anesthetics are used considerably particularly sodium pentothal. It is best given in small doses repeated if necessary with skilled observation of the patient. Complete relaxation is liable to be accompanied by dangerous respiratory depression.

In the late treatment of fractures an anesthetic is sometimes advised when it is necessary to manipulate joints and break up adhesions. This is a dangerous procedure and should never be resorted to until every other method of stretching has been tried.



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## PATHOLOGY AND REPAIR OF FRACTURES

The intelligent care of fractures demands as an essential prerequisite a general knowledge of the pathologic condition accompanying the injury, the factors involved in the process of repair and the correlation of these with the disturbed physiology which one hopes to restore to normal. Without such a knowledge a fracture bids fair to remain an *x ray* picture throughout its course. Such a point of view can never lead to really adequate treatment. A detailed discussion of the minutiae of pathology and repair involving the theoretical conceptions of the specific mechanisms involved and of the biochemistry and minute cellular activities brought into play has no place in this brief presentation. These are largely matters of academic interest. Merely a broad concept of what is known to occur following a fracture and during the healing process will be presented here, and an attempt will be made to point out the way in which the process is reflected in the signs, symptoms and disturbed physiology and what these sign posts indicate with regard to treatment. Everyone knows what ecchymosis is and that it is one of the cardinal signs of fracture. But not everyone realizes that its location, the time of its appearance and its extent may be valuable indications pointing to important pathologic occurrences and vital therapeutic needs for the best results.

The consensus today, based on both clinical and experimental evidence, supports the view that the repair process following fracture is a *local* phenomenon. The general state of the patient's health, his age (with the exception of infancy and childhood), the existence of acute or chronic general disease (lues, arteriosclerosis, nephritis, tuberculosis, arthritides, cardiac disease, etc.) and the existence of generalized metabolic disturbances (osteomalacia, rachitis, scurvy,

diabetes, etc.)—none of these has any proved effect on the rate or degree of healing of a fracture. Of the various endocrine functions there is not one which has been shown to have any appreciable effect on the actual primary healing process in the presence either of excessive or of diminished activity. It is true that individual researches may indicate to the worker some effect (the literature is full of such examples) but for each contribution of this type one may find from apparently just as reliable a source a contradictory conclusion. Despite suggestive reports from certain reliable authors of a correlation between the serum calcium and phosphate values and their interrelationship with fracture healing, extensive checks have failed to support this point of view. More over a patient with a negative calcium balance and with marked generalized bone decalcification has after sustaining a fracture shown a normal or increased rate of fracture healing, *later decalcifying the callus to the same degree as the rest of the skeleton*. On the basis then of clinical and experimental findings by and large, major attention should be devoted to the local problems involved in the pathology and healing of fractures.

Consider what actually happens. At the time of injury the bone is broken and coincidently there is a variable degree of damage to the surrounding soft parts by laceration or contusion. If the laceration extends through the skin, allowing communication between the fracture and the outside air, the fracture assumes a special significance as a *compound fracture*. The significance of compounding will be considered later.

The blood free in the tissues and the dead tissue resulting from the injury constitute irritants. In fact, even with a moderate pathologic condition the patient may show within a few hours a rise in temperature, an increase in the leukocyte count and a raised sedimentation rate. There is in effect an aseptic inflammation, the parts surrounding the fracture are rapidly infiltrated by hemorrhage, edema and inflammatory exudate. Here then is the first clinically applicable knowledge of pathology. At the time of injury and for a variable period of from ten to thirty or forty minutes after injury the part may be said to be in a state of local

shock. It is analgesic after the initial momentary sharp pain of the fracture and its neuromuscular apparatus is practically paralyzed. A patient seen in this period will state that the arm or leg is numb. It will be markedly flaccid and relaxed. It is in this stage that a bystander by merely pulling on the part can readily and accurately reduce a dislocation or even a badly displaced fracture with practically no pain to the patient. It happens practically every day on some field of sport or athletic activity and is accepted as a matter of course even by the layman. But only within the last few years has there been an appreciation of its application to the emergency use of traction through the application of the Thomas type of arm and leg splints with windlass traction which is now the approved standard of the American College of Surgeons as represented by its Fracture Committee (See section on First Aid Treatment of Fractures.) The use of immediate emergency traction on fractures if universally adopted will constitute the biggest single advance in the treatment of fractures in the present generation.

Following the passing of this short period sensation returns to the part and with pain comes muscle spasm and with muscle spasm there is the risk of increased deformity and additional interference with the blood vascular and lymphatic circulation. Within a few hours hemorrhagic and inflammatory infiltration has changed the shortened and spastic muscles from elastic extensible structures to hardaceous semisolid masses which can be stretched only with great difficulty even with damage. These muscles now constitute a mechanical bar to reduction. *Had the fracture been reduced and held before this happened the hardened and distended tissues would act instead as splinting for the reduced fracture.* This is the basis for the general principle that a fracture should be reduced as soon after injury as possible. Since this process is rapidly progressive and is complete within from six to eight hours it becomes obvious that one should think of reduction in terms of minutes after injury not in terms of hours or days. An hour spent in waiting around an accident ward may mean the difference between ease and difficulty of reduction.

This is of major importance in any fracture of the shaft of a long bone and of less practical significance in fractures such as Colles fracture at the wrist and uncomplicated malleolar fracture at the ankle where muscular resistance is not so potent a factor. It is however a matter of considerable import in cases which require skin or skeletal traction. When a patient has waited overnight to have pin or wire or adhesive traction applied what might have been an easily accomplished reduction by the stretching of elastic and extensible muscle bellies with a minimum of trauma may turn out to be an indifferent reduction accomplished with difficulty through the necessity of dealing with infiltrated and relatively inextensible inelastic muscle masses. The blame for failure is placed on the shortcomings of traction and suspension instead of on ignorance of or lack of consideration for the pathologic change going on during the overnight wait. If emergency fixed traction had been applied in the interim much of the difficulty would have been obviated. When a wait is necessary this type of traction is the best means of minimizing the potential damage due to delay.

Following this pathologic change there is clotting *i. e.* laying down of a fibrin network in the hemorrhage and exudate in the tissues. This network joins the bone ends and adjacent soft parts in a web of interlacing fibrils along which tissue repair is to take place. The remaining fluid portions of blood and exudate seep to the surface slowly along the tissue planes if the soft parts about the fracture are but little lacerated or appear rapidly beneath the surface if there has been extensive laceration of the soft parts. The ensuing discoloration of skin due to the presence of the blood pigment in the fluid portion of the blood is known as ecchymosis. It is obvious that an early rapid appearance of ecchymosis at the fracture site indicates a large amount of tissue damage proportionately greater the deeper the involved bone lies from the skin. *Ipso facto* it indicates the need for methods of treatment which will allow maximum early attention to the pathologic condition of the soft parts. On the other hand ecchymosis which appears late particularly at a point distant from the fracture indicates a

minimal amount of soft part damage with a more favorable prognosis for the early return of function and a less urgent necessity for intensive early care of the soft parts. If the elbow joint is involved for example as in fractures of the radial head or lower humerus and in dislocations very early ecchymosis on the front of the elbow (sometimes within an hour from the time of injury) indicates extensive laceration of the joint capsule and brachialis anticus and a threat of ossification about the front of the elbow. Special treatment is urgently needed under such circumstances.

As a result of the death of the hemorrhage and progressive circulatory stagnation (lymph and blood vascular) following rapidly after fracture the pH of the local tissue fluid becomes acid. With this acidity there occurs over the next week or ten days a decalcification of the fracture site. These are the facts whether or not they are correlated or merely contemporaneous is at present in the field of speculation. The calcium so removed from the fracture site is held locally in the soft parts probably by an adsorption affinity for fibrin and collagen. The latter part of this statement is possibly speculation; the first part is fact.

Coincident with this chemical change the healing process proceeds as with any other wound, by the growth of new fibroblastic cells along the fibrin network from all available connective tissue sources—marrow cavity with its so-called endosteum, periosteum and fascial planes and muscular stroma if they are opened into by the fracture.

This healing process is what one would expect in any wound and is explicable if at all, on the same basis as all wound healing. At some stage during the process calcium is deposited in the healing tissue to surround the cells and the tissue then is called *cellus* instead of granulation tissue. Whether or not osteoid tissue (early callus) contains calcium or merely a preosseous substance in which calcium is deposited (Leriche) whether or not specific bone forming cells are involved in the process either by direct growth and migration of osteoblasts from adjacent bone and periosteum and endosteum or by 'metaplasia' of connective tissue cells in reply to the physiologic de-

mand and whether or not ferment activity (phosphatase) is an integral part of the story and if so whence the ferment is derived are at present matters of academic interest. The practical clinical application of this phase of the story lies in the fact that the consensus is that the calcium deposited in the newly formed connective tissue is for the major part derived from local decalcification at the fracture site and that its deposition occurs coincidently with the alteration of the pH of the tissue fluids locally toward the alkaline side as a result of removal of tissue death products and correction of stagnation of tissue fluids by a restoration toward normal of the lymphatic and blood vascular circulatory efficiency of the part.

Moreover there is a great deal of evidence to support the viewpoint that this deposition of calcium into the healing tissue to form bone can occur only while the tissue is still undifferentiated. Once the healing tissue becomes adult formed fibrous connective tissue no bone formation occurs. If this is so and if our ideas on the deposition of calcium as a result of phosphatase activity within a limited pH range approaching the alkaline side are correct it would seem that if the acid pH phase is prolonged by reason of the amount of tissue death or by reason of a circulatory status which makes impossible the carrying away of the products of tissue death the healing tissue may differentiate before any calcium deposition can be effected with the result that the healing remains fibrous (the so-called non union) or the deposition of calcium in the lower pH ranges may be so slow that so-called delayed union occurs.

In this understanding of the process lie possible explanations for many of the apparent vagaries connected with fracture healing. It is to be kept in mind that once local destruction of intrinsic bone circulation has occurred as a result of fracture the most important factor in the maintenance of efficient nutritive and scavenger levels is the available accessory circulation of the soft parts—blood vascular and lymphatic which can operate at physiologic levels and substitute for the destroyed circulation to the bone. On this factor hinges to a large extent how much growth of healing granula

tion tissue can occur and how soon deposition of calcium in this tissue can take place. The neck of the femur presents an excellent example of this phase of the problem.

As will be noted from the descriptive paragraph beneath figure 360 the amount of healing tissue produced is dependent on the supply of available *vascular soft parts* and the calcification of that living healing tissue to produce bone is dependent on the *vascular efficiency of the region* in reference to returning the reaction of tissue fluids toward normal by reason of correcting the local stagnation of tissue fluid and the removal of products of tissue death hemorrhage and exudation before the healing tissue becomes differentiated into adult fibrous connective tissue.

The study of these phenomena has led to an appreciation of the fact that attention to the circulatory efficiency of the part particularly in its more minute phases rather than in the major vessels is a big factor in promoting normal or rather average healing. This has a very definite bearing on the present day tendency toward pin fixation and operations as methods of choice in many cases when they can be combined with early active mobilization of the part early in intensive physical therapy and elevation since those three adjuvants in that order are the most effective means of improving the local circulatory status.

The pathologic condition of the fracture line is a matter of considerable importance in an evaluation of the suitability of various methods of treatment in a given case.

Some guides for fracture treatment based on the foregoing discussion of wound healing can be briefly set down as follows:

1 First aid in fracture cases should aim at as extensive and complete immobilization of the part as possible and should include fixed traction if possible applied as soon after injury as possible and with as little trauma as possible.

2 Shock and injury should be treated coincidently. *Except in moribund cases it is a mistake to treat shock until the patient is normal and then to treat the fracture.* The treatment of shock should be carried out while the fracture is being given early definitive treatment.

3 Reduction should be accomplished

before the muscles and soft parts have lost their elasticity by reason of infiltration by exudate and hemorrhage. This is just as true for traction suspension open reduction and fixation pin fixation or any other method as it is for manual manipulation and plaster fixation. It means that reduction by traction suspension should be complete within eight to twelve hours that open reduction should be performed within that time if possible and that pin fixation should be applied and should attain reduction with fixation by plaster or apparatus within that time.

4 If the patient is seen after the loss of elasticity in the tissues has occurred intensive effort should be made to get rid of the pathologic accumulations in the tissue and reduction by any means should be delayed until elasticity is restored unless some urgent necessity for it exists. Under proper use of splinting position physical therapy and muscle stimulation this delay should rarely be more than forty eight or seventy two hours and will often be less than twenty four hours.

5 That method of treatment which allows the most active function of the extremity during bone healing is if it can be adequately carried out the best method from the dual standpoint of successful bone healing and of short convalescence time. Whether or not the theoretically best method is practically applicable in the individual case depends upon the analysis of the patient and his lesion (bone and soft parts) upon the qualifications of the doctor and upon the organization and equipment available.

6 Physical therapy should be regarded as an adjunct to or an inadequate substitute for active function and both patient and doctor should thoroughly understand this.

7 Postreduction immobilization should aim at as rigid fixation of the fragments as possible coincident with as extensive mobilization of the extremity as is compatible with the method of treatment used.

8 No matter what the method used its general purpose should be metaphorically to 'wish the fragments into place with the immediate abolition of all pathology to hold them in position by moral persuasion and to

let the patient immediately go about his regular business. How closely this ideal can be approached depends upon the method used but the approach should be in each instance as close as the limitations of the method will allow.

9 The necessity for after treatment and rehabilitation measures is in inverse proportion to the efficiency with which the principles of treatment have been carried out by the method used.

10 Fractures heal primarily by the formation of bone in the soft parts about the fracture site and the circulatory efficiency in these soft parts is a vital factor in the process.

11 In compound fractures the treatment of the wound and adequate reduction and fixation of the fracture should be coincidental and should be accomplished just as soon in terms of minutes after injury as possible. Early wound treatment with delayed reduction and fixation is a mistake.

The pathology of the displacement of fragments has a definite bearing on the methods of reduction and should together with the resisting forces constitute the basis of any intelligent effort at reduction.

Lastly it is essential to recognize that for each region of the body there are important soft part structures liable to damage and that the examination of the patient includes elimination of the possibility of injury to them since the soft part lesion if present may constitute an urgent reason for altering from the beginning the method of treatment ordinarily used for the fracture in question. For instance in a lesion involving the middle third of the humerus the radial nerve is frequently injured. If this is not noted at the time of the original injury it may not be discovered until six or eight weeks later when immobilization is removed with resultant difficulties in the handling of the nerve injury. Similarly the median nerve at the wrist may be involved in badly displaced Colles fractures and in lunate dislocations. The peroneal nerve is often involved in lesions about the fibular neck or by direct violence in this region though the fracture is of the tibia. Lesions about the internal humeral condyle may involve the ulnar nerve and those about the external condyle may involve radial or superficial radial

nerves. Dislocation of the shoulder or surgical neck fractures frequently involve the axillary nerve. Supracondylar fractures of the humerus with displacement are the commonest cause of Volkmann's ischemic contracture and the local tension about the front of the elbow and the state of the radial pulse before reduction after reduction and in the immobilized position must be carefully noted. One frequently sees cases in which prompt and adequate provision for the correction of the circulatory embarrassment has aborted a Volkmann's contracture the very early signs of which were already present when the patient was first seen. The author has seen many cases in which if the ordinary routine procedures had been followed without a careful check on the radial pulse throughout Volkmann's contractures would undoubtedly have been imminent. Unfortunately in many cases a check on the radial pulse is not considered as part of the examination and handling of a lesion of the elbow and there are disastrous results. It is only a knowledge of the peculiar pathology of supracondylar fractures which makes the name of the fracture elicit immediate concern for the radial pulse.

There are numerous examples of impending disaster lurking in the lesions of the soft parts complicating fracture. Each region of the body has its soft part trap so to speak and it behooves the surgeon to know what it is so that it can always be looked for anticipated and if possible avoided.

#### DELAYED UNION AND NON UNION OF FRACTURES

On the basis of experimental procedures clinical observation and roentgen studies the present day conception of the problem of delayed union and non union may be epitomized in the following brief statements the clinical bearing of each statement being briefly summarized. The details of the supporting evidence are furnished in the articles listed in the bibliography.

I All fractures heal as do wounds elsewhere unless there is a mechanical chemical or anatomical bar to healing. This healing in common with that of wounds of the soft parts takes place through the medium of new connective tissue known as granulation

tissue. When referring to delayed union and non union one in reality refers to a delay or failure in the process of calcium deposition in the healing connective tissue which is commonly designated as new bone formation. The anatomical bar to healing lies in the absence of a sufficient accessory circulation to compensate for that destroyed by trauma and to remove adequately and rapidly the products of tissue death. Such regions of the body even under apparently optimum conditions are characterized by a slow average healing time and by the frequent occurrence of delayed union and non union in adults. The neck of the femur (sub capital or midcervical), the junction of the lower and middle thirds of the tibia, the scaphoid of the carpus (proximal half) and the base of the fifth metatarsal are characteristic regions.

In patients who have fractures in these regions and simultaneous fractures in regions not so characterized there is no perversion of healing in the latter, all other factors except location being equal.

*II Variations in the character and amount of the healing process in bone following fracture are dependent on factors limited to the region of the body involved quite independent of the subject involved.*

Slow union and non union in the adult are not dependent on the age (*per se*) of the patient on his general state of health on the presence of chronic general disease such as syphilis or cardiovascular or renal disease on general wasting due to other causes on general metabolic disturbances affecting either the general calcium and phosphorus metabolism (osteomalacia) or other phases of metabolism (diabetes) or on acute infectious disease. Non union except for mechanical reasons is practically never seen in children.

*III The four factors involved in the mechanism of the healing of fractures and capable of being clinically influenced are (1) the local pathology (2) the growth of granulation tissue (3) an available local source of calcium for the ossification of the healing tissue and (4) a proper biochemical status of the local tissue fluids throughout the healing process.*

**1 Local Pathology**—The items of importance under this factor are (a) The

amount of tissue necrosis. When massive it destroys the available sources for the growth of granulation tissue and under all circumstances creates a pH to the acid side (often markedly so) in the hematoma and tissue fluids about the site of the fracture. This pH is of importance in the production of the local source of calcium and is the essential early stage of the biochemistry of the tissue fluid. Its persistence interferes with calcium deposition.

(b) The hematoma or blood effusion at and about the site of the fracture influences the growth of granulation tissue through its fibrin content and the possible persistence of its fluid content *in situ* and also through the establishment of a local source of calcium under proper conditions of pH in the tissue fluid by acting essentially as a decalcifying fluid and through adsorption affinity between calcium and its fibrin content holding the freed calcium *in situ*.

(c) The circulatory status of the part (including the lymphatic and tissue fluids) in the early and late stages of fracture healing. Its significance lies in its influence on the growth of granulation tissue and on the establishment and utilization of a local source of calcium through its influence on the pH of the tissue fluids.

(d) Chemical and physical influences through their effect on the growth of granulation tissue and the biochemical status of the part. Under the former may be noted the therapeutic use of chemicals locally (disinfectants, etc.) and infection and under the latter the use of such agencies as roentgen rays and diathermy and constant movement of the fragments.

(e) The mechanical element i.e. the interposition of living or dead material impermeable to the growth of granulation tissue between the fragments.

**2 Growth of Granulation Tissue**—The items of importance under this factor are as follows: (a) All other factors being equal the amount of callus produced is directly proportional to the amount of granulation tissue produced.

(b) The destruction of available sources for the growth of granulation tissue.

(c) The anatomical characteristics of the part regarding sources for the growth of granulation tissue and accessory circulation.

(d) The amount of fluid persisting for a long period at the site of the fracture

(e) Elements *d* and *e* mentioned under local pathology (chemical and physical influences and the mechanical element)

3 Available Local Source of Calcium.—The items of importance are the amount of bone necrosis the density and degree of fragmentation of the necrotic bone the influence of fibrin and collagen in fixing the calcium locally through chemical affinity and the biochemical status of the local tissue fluids

4 Proper Biochemical Status of the Local Tissue Fluids Throughout the Healing Process.—This factor involves the necessity in the local tissue fluid of a pH on the acid side in the early days following the fracture in connection with the establishment of a local source of available calcium and a reversion of the pH toward the alkaline side before the calcium made available can be to any extent deposited in the new tissue to form bone. The constituents normally involved in this phase of the process are the amount of tissue necrosis and the circulatory status (blood and lymph) of the part

What, then, can be done to prevent delayed union and non union? The objects of concern are as follows:

1 Early and accurate replacement of displaced fragments with assurance at the time of reduction that there is no interposition of tissue

2 The restoration to normal of the lymph and vascular circulation as rapidly as possible through elevation of the part early physiotherapy and the use of functional muscular activity whenever possible

3 The meticulous care of wounds in cases of compound fractures. Gentleness and conservation of sound tissue are not incompatible with thorough and efficient debridement. It pays to be conservative on the score of considering a debrided wound safe to sew up tightly. Chemical disinfection of a wound is not desirable. No method of wound treatment which creates tension in the tissues can be considered sound.

Where facilities for operative work on bone are of high standard as regards equipment technique and personnel many feel that in an open fracture rigid fixation of the frag-

ments by plate or screw at the time of the debridement with the wound left open is justified through minimizing the chances for delayed or non union by eliminating the foothold for infection engendered by constant movement of the fragments. Such a procedure is never justified unless the facilities for carrying it out are as specified.

4 Where the facilities for operative work on bone are of the highest standard as regards equipment technique and personnel it is today the belief of many that operative reduction with internal fixation sufficiently rigid to permit postoperative active mobilization in balanced suspension is the ideal method for fractures of the long bones in adults. It is certainly very doubtful whether operative reduction and internal fixation are justifiable except on the basis of absolute necessity unless rigid fixation can be secured since the early active use of the musculature as an aid to the minute circulation is one of the chief recommendations for the use of the method. Any necessity for postoperative immobilization nullifies this important advantage. Moreover it is felt that if open reduction is indicated it should be done within the first few hours after injury in order that the blood dead tissue and inflammatory exudate can escape through the operative wound or can be removed. This minimizes the burden placed on the local circulation in removing products of tissue death in order that the pH of the tissue fluids can revert toward normal as rapidly as possible thereby facilitating the early deposition of calcium in the undifferentiated healing tissue.

When the fracture lies in a region characterized by slow or indifferent healing the rigid internal fixation can be augmented by the use of osteoperiosteal or other forms of grafts as prophylaxis against non union.

It is to be strongly stressed that the use of operative reduction as a method of choice can be conscientiously adopted only when exacting conditions as to organization equipment personnel and technique can be met and when the mechanical principles involved in securing rigid fixation capable of standing functional strain are thoroughly understood.

How should one treat non union? By creating the essential factors for new bone

formation at the site of fracture—death of tissue—adequate granulation tissue—a local source of calcium and an adequate circulatory status for the part—not for the bone alone

A bone graft, there are many reasons to believe does not grow but acts as a source of calcium for the calcification of the healing granulation tissue and as one of the sources for the enzymes concerned in the calcium deposition. The removal of fibrous tissue and of sclerotic bone aids circulatory augmentation and granulation tissue growth and invasion. The graft is rarely efficient enough fixation to allow of early active function, particularly since osteoperiosteal or chip grafts should be the most effective type and are so clinically and experimentally. If possible there should be added to the graft the rigid fixation obtainable from plate screw or other rigid means when feasible, followed by early active function. The postoperative treatment should follow the lines laid down for the prevention of delayed and non union in a fresh fracture.

In addition to the prophylactic measures against delayed and non union referred to previously and the operative treatment of the conilit in after it has occurred the following measures are in more or less common use on the basis of the rationale cited in each instance.

1 "Needling" of the fracture site consisting of passing repeatedly about and through the fracture site a sharp heavy needle. This produces a certain amount of tissue death and hemorrhage about and between the bone ends and sets up a variable degree of inflammatory reaction with concomitant circulatory change. According to one school of thought this may "stimulate" osteoblasts to produce bone. According to the other it recreates the original pathological conditions of the fracture and is followed by ossification in accordance with the rationale suggested under the discussion of fracture repair. At any rate this procedure is followed by union in a certain number of cases. There is no criterion whereby one may gauge which fractures are apt to respond to this treatment.

2 The injection of whole blood between and about the bone ends. The same discussion applies here as in the case of "needling" without injection.

In addition to whole blood various other milky imitating substances have been used with similar results.

The use of calcium emulsions for injection has been attempted in the hope of augmenting the available local supply of calcium to be used in callus formation. In a fresh fracture such calcium is always available from the dead bone at the fracture site. In instances of late non union this is not the case and theoretically injection should supply a definite need. While success-

ful use has been reported of this procedure it does not seem on the whole to be any more valuable than plain needling or the injection of other substitutes.

3 The use of Bier's hyperemia intermittently over a considerable period of time. The effect here is on the circulatory status of the part and may work through the biochemical status of tissue fluids so created. At any rate its use is at times followed by union.

4 The tapping or gentle malleting of the bone at the fracture site (when it is subcutaneous) intermittently over a period of time. This accomplishes perhaps the same result as 1 and 2 without penetration of the skin. It is subject to the same interpretation as those procedures.

5 The initiation of weight bearing in cases of fracture of the lower extremity as by so-called "Roller walking irons," walking specs and braces. Here again there are two views as to the mechanism of the healing sometimes induced, that it is a "response by osteoblasts to a physiologic demand" or that the inflammatory reaction induced by weight bearing in the presence of non union acts in accordance with the rationale of callus formation as suggested under the description of the repair process in fractures. Here again the procedure is sometimes successful and sometimes not with no known criteria whereby one can estimate the probabilities.

6 Boring numerous holes (after open exposure) in all directions through the fracture line from both fragments using a drill. This creates channels through sclerotic bone for revascularization of the fragments, leaves in the channels and surrounding soft parts a certain amount of bone debris removed by the drill and sets up the original status of the pathologic condition. It is subject to the same remarks as is the suggested mechanism of fracture healing under the discussion of that subject. It is perhaps the most successful of the methods described outside of grafting procedures and may be followed by walking plaster or brace weight bearing.

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## FRACTURES OF FACIAL BONES

Fractures of the facial region may be divided into four principal groups: (1) mandible (2) maxilla (3) zygomatic or malar bone and (4) nose. These may be sustained separately or together and may be complicated by injury to the overlying soft tissues.

**Fractures of the Mandible.**—The mandible is fractured more often than any other bone of the face, usually by direct violence such as a blow, a fist, an automobile accident, a gunshot wound or a fall on the chin or during the extraction of a tooth. In some cases the fracture occurs at a point some distance from the place of impact.

**Location of the Fractures.**—The mandible is fractured in one place in about two thirds of the cases and in two or more places in one third. The commonest single seat of fracture is the angle, closely followed by the mental foramen. Fractures of the symphysis and the neck of the condyle occur in 7 or 8 per cent of the cases, while fracture of the coronoid process is very rare. In cases of double fracture, a break in the region of the mental foramen on one side and a break at the angle on the opposite side are found most frequently.

**Diagnosis.**—Fracture should be suspected in every case of trauma to the region of the lower jaw until careful examination proves

otherwise. In many cases a patient is discharged from the accident ward of a hospital after receiving treatment for simple lacerations or contusions of the face only to return several days later with symptoms of an infected or unreduced fracture. With a history of trauma the most important points in diagnosis are as follows: inability of the patient to bring the lower teeth into correct occlusion with the upper teeth; severe pain at the site of fracture when the patient attempts to bite a hard object such as a wooden tongue blade inserted between the teeth; and preternatural mobility of the teeth on each side of the fracture. In a fracture through the region of the mental foramen the chin fragment is drawn down by the depressor muscles while the fragment posterior to the fracture is drawn up by the levators (temporal masseter, internal pterygoid). In fracture through the ascending ramus or the neck of the condyle there is shortening from angle to condyle; hence the chin and lower incisor teeth deviate to the affected side. When the jaws are closed the upper and lower molar teeth meet sooner than those of the opposite side. It is rarely necessary to subject the patient to painful manipulation to elicit preternatural mobility or crepitus. Good x-ray plates of both sides of the jaw, including both condyles, should be made in all cases of suspected fracture of the mandible. The region of the symphysis is best studied roentgenographically by means of a  $2\frac{1}{4} \times 3$  inch occlusal film. The x-ray plate is valuable aid in determining the direction of the fracture, comminution, injuries to the roots of teeth and involvement of teeth in the fracture. It plays only a minor part in ascertaining the position of the fragments.

**Treatment.**—Practically every fracture which occurs in the part of the mandible occupied by teeth is compounded into the mouth and is exposed to infection. Early removal of tooth roots exposed in the line of fracture of badly diseased teeth wherever situated and of tartar deposits minimizes the danger of infection. Early immobilization of the fragments also reduces the tendency for infection from the mouth to work its way down in the fracture line. Throughout the course of treatment the patient should be encouraged to use a tooth brush and a

mouthwash containing hydrogen dioxide. The cooperation of the patient is essential in maintaining cleanliness of the mouth. No amount of cleansing by a second person will compensate for negligence on the part of the patient himself.

**Fixation of the Fracture**—In the mandible more than in any other region accurate realignment of the fragments is necessary, because the slightest deviation of the parts (except in edentulous patients) will result in malocclusion of the teeth and consequent interference with proper mastication. The fundamental principle therefore in treating these cases is fixation of the fragments so that the teeth of the lower jaw will be in proper relationship to those of the upper. Much space is given in surgical texts to obsolete methods which are not practicable for the surgeon who sees the average case. Re-

molars on both sides of upper and lower jaws, the upper first incisors and the lower four incisors, and joining these three pairs of approximating wires with three single wires passed through the eyelets and twisting the ends together after the teeth have been brought into proper occlusion. If the teeth usually employed for wiring are absent, diseased or otherwise unsuitable as attachments, then other teeth are used; the aim being to have three pairs of eyelet attachments. Occasionally, where the teeth are not sufficient in number and stability for direct application of eyelet wires, a half round wire arch of plain heavy German silver is attached to the labial aspects of the teeth with wire ligatures. The teeth usually must be wired together for from four to six weeks to obtain union of the fracture. The patient must be kept on a liquid diet and fed

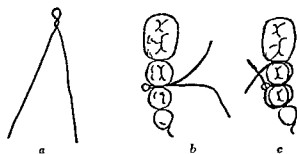


Fig. 30.—Fixation of a fracture of the mandible: *b*, the eyelet method; *a*, Eyelet wire; *b*, eyelet wire inserted between the premolar teeth; *c*, eyelet wire passed around the teeth, the ends ready to be twisted.

liance on a head bandage alone in the ordinary cases has no more value than would a mere bandage in a fracture of both bones of the forearm. Direct wiring or plating of the fragments should not be attempted in recent fractures which communicate with the mouth. In 90 per cent of cases of fracture of the mandible, no matter where situated, adequate fixation can be obtained by fastening the lower to the upper teeth by means of wire ligature according to the principle of Gilmer. The other remaining 10 per cent may require cooperation of the dental laboratory for the preparation of the more complicated interdental splints. With a little practice and attention to details, the surgeon can readily master the technic of application of the wires. Briefly, the method consists in fastening 6 inch strands of #4 gauge brass wire with an eyelet made in the middle of each strand around the necks of the pre-

through a tube. There is usually no difficulty about this, the liquid passing easily through spaces between the teeth or back of the last molars. It is never necessary to extract a tooth to provide space for feeding. Infection sometimes occurs about the site of fracture requiring incision and drainage, removal of sequestrums, etc. There are certain complicated types of fracture of the mandible requiring more elaborate methods of fixation which are described in detail in various specialized textbooks. Skeletal fixation is occasionally used in cases in which teeth are not available.

**Fracture of the Maxilla**—Fractures of the maxilla are much less common than those of the mandible. They are often as o-

ments is usually due to the direction of the traumatizing force and sometimes to gravity.

Most fractures of the maxilla fall under the following heads: (1) fracture of the alveolar process alone; (2) unilateral fracture across the facial aspect above the roots of the teeth and through the hard palate; and (3) bilateral horizontal fracture at

be fractured or teeth may be broken off. It is usually necessary to remove the detached fragment together with the teeth in it.

2. *Unilateral fracture of the maxilla* is usually caused by direct force coming from in front or from one side. There are symptoms of contusion of the side of the face and the entire maxillary dental arch on the

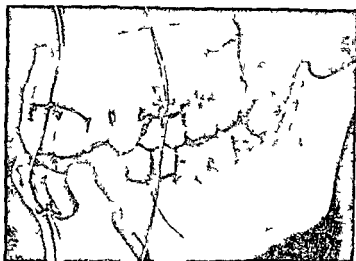


Fig. 306—Connecting wires are passed through the eyelets.\*

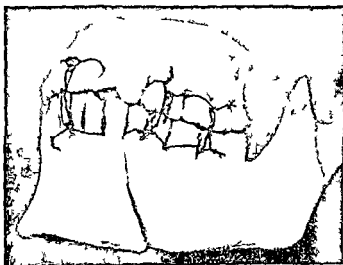


Fig. 307—The teeth are fastened in occlusion by means of twisting the ends of the connecting wires.\*

some level above the hard palate, sometimes accompanied by extensive comminution and crushing of the upper portion and complicated by fracture of the nasal maxilla and other bones.

1. *Fracture of the alveolar process* may occur in the extraction of teeth or may be due to a blunt localized force. In addition to the break in the bone, tooth roots may

side of injury is usually depressed. By gentle manipulation mobility of the fragment can be demonstrated. Many cases can be successfully treated by pushing the fragment back in place until the teeth are in occlusion and then wiring the teeth of the sound side of the maxilla to those of the mandible.

\* Ivy and Curtis: *Fractures of the Jaws*, Lea & Febiger, Philadelphia.

3. *Bilateral horizontal fracture* is usually caused by a direct blow from in front, such as occurs when a driver's face strikes the steering wheel of a suddenly arrested automobile. In the majority of cases the entire upper jaw is displaced backward and sags downward posteriorly so that the upper teeth are distal to the lower and only the last molars occlude, leaving a space between the incisors in front. The entire dental arch can be moved as a unit. The hard palate may be intact, or the case may be complicated by a longitudinal median fracture with either spreading or narrowing of the dental arch.

guided into position, and after a week or ten days, when occlusion of the upper and lower teeth has been regained, they can be fastened together with wire ligatures for a period of three or four weeks until union is complete. Fixation of upper jaw fractures can also be accomplished by means of traction wires from the upper teeth on each side piercing the cheeks and attached to bars on a plaster of paris headcap (Federspiel).

Fracture of the malar, or zygomatic, bone is always due to direct violence, and usually breaks occur at or near its junction with other bones, the body of the malar being depressed and often impacted (Fig 308).



Fig 308.—Skull showing usual lines of fracture of malar bone.\*

*Treatment.*—Fixation by means of the mandibular teeth is not advisable at first because of the mobility of the lower jaw. Support should be obtained from the cranium by means of a head apparatus and a reversed Kingsley splint. The writer has had made an emergency apparatus of this type which can be kept on hand in two or three sizes so as to be immediately applicable. It consists of a heavy metal arch bar to be secured to the outer surfaces of the upper teeth with wire ligatures and provided with arms extending out of the mouth on each side for attachment to a plaster of paris headcap with straps or heavy elastics. By this means the upper jaw can be gradually

*Symptoms and Diagnosis.*—A depression is seen in the cheek on the side of the injury, just below the outer corner of the eye while lower down the cheek appears to be swollen. The entire side of the face may be so swollen and edematous as to mask the deformity. Diplopia may be present as a result of the depression of the floor of the orbit or of interference with the action of the ocular muscles. Subconjunctival ecchymosis is seen. Epistaxis usually occurs because of rupture of the mucosa of the maxillary sinus. The patient complains of numbness of the side of the nose and lip, owing to injury of the

\* Ivy and Curtis: *Fractures of the Jaws*, Lea & Febiger, Publishers.

infrorbital nerve. Palpation reveals tenderness and irregularity of outline at four points over the zygomatic arch the junction of the malar with the frontal bone the lower rim of the orbit and where the malar bone joins the maxilla below. A ray examination to show the skull bilaterally in the vertical position will clearly outline the depressed malar bone. There may be difficulty in closing the mouth because of interference with the coronoid process.

*Treatment* consists in elevation of the depressed bone as early as possible. After two weeks this may be very difficult as union occurs rapidly and a permanent deformity may remain. Many methods of elevation have been advocated. The most efficient in the writer's hands is that suggested by Gillies which consists in lifting up the bone with a long flat elevator inserted through a small skin incision in the temporal region. The incision goes through the temporal fascia and the elevator slips down on the surface of the temporal muscle beneath the malar bone. The necessary amount of elevation can be controlled by placing the fingers on the cheek. No fixation is necessary. The incision is closed with a suture and leaves no visible scar since it is above the hair line.

Fracture of the nasal bones is also due to direct violence. The nasal bones may be thrust directly backward with or without comminution the septum being crushed or buckled beneath them or the bones may be displaced to one side.

*Treatment*—It is desirable to replace the bones if possible before swelling masks the deformity that is within the first few hours after injury. If treatment is postponed for two weeks or longer union may require dislodgment with a chisel. Fractures with little or no displacement do not require treatment. In recent cases it is generally possible to elevate the depressed bones by pushing them up with a closed pair of curved Kelly forceps inserted in the nostril and molding with the fingers externally. The use of intranasal splints is not as a rule satisfactory but the nose may be packed with gauze soaked in liquid petrolatum to aid fixation and to control hemorrhage. When the nasal bones tend to sag down a mattress suture of fine wire passed beneath them through the skin from side to side and tied over the lead plates

resting on the skin will often aid in preserving the prominence of the bridge of the nose. A recent case with lateral deviation can also be corrected by manipulation and recurrence of the deformity may be prevented by a scheme suggested by Blair. This consists in passing a fine wire with a long straight needle through the skin on the side of the deviation one end between the nasal bone and the nasal process of the maxilla and the other end below the lower border of the nasal bones. The ends of the wire cross the septum and come down into the vestibule of the mouth on the opposite side where they are attached to a premolar or a molar tooth. The loop of wire thus catches the outer angle of the nasal bone and holds the bridge over in place. The skin can be protected from the pressure of the wire by interposing a thin lead plate or by incising the skin between the points of insertion of the wire allowing it to bury itself against the bone.

R. H. IYI

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#### FRACTURES OF HYOID BONE, THYROID AND CRICOID CARTILAGES, AND TRACHEA

Fracture of the hyoid bone occurred more frequently in earlier days when garroting was the favorite crime of violence rather than shooting with a modern submachine gun. Fortunately the great flexibility of the hyoid bone and surrounding structures gives it unusual protection. The incidence given in various statistics on fracture for this accident is about 0.002 per cent.

*Diagnosis*—The condition is very serious. There is a history of direct violence followed by severe pain in the throat, dyspnea, dysphagia and dysphonia. Protrusion of the tongue produces suffocation. One or both of the cornua may be broken in the midline or near the junction with the body of the bone. The fragments generally penetrate the soft

tissue of the pharynx and profuse bleeding may occur. An x-ray examination made in a lateral oblique position is very helpful in giving a clear idea of the fracture and the relation of the fragments.

**Treatment**—One finger should be inserted into the mouth, the other hand should be placed over the bone outside the neck and reduction obtained by manipulation. The patient should be kept absolutely quiet by means of sedatives. All blood saliva and exudate should be frequently and carefully removed by suction. Local application of ice to the neck adds to the patient's comfort and prevents swelling. It is most important to have him avoid swallowing for four or five days, all feeding being done per rectum.

**Fracture of Thyroid and Cricoid Cartilages**—The thyroid is more often involved, the ratio being about 4 to 1.

**Diagnosis**—There is a history of trauma—blows, strangulations, attempted hanging and falls being the common causes. The symptoms are very similar to those noted in connection with fracture of the hyoid bone. The pain on swallowing is extreme and there is usually more cyanosis. If there is not too much external edema, abnormal mobility and displacements of the fragments can be observed.

**Treatment**—Immediate tracheotomy is essential. There is always edema of the mucous membrane. The blood and exudate should be removed by suction. It is usually safe to feed the patient by means of a nasal tube.

**Fracture of the trachea** is a very rare condition, practically always associated with contusions and tears. Sudden violent extension of the neck (such as hanging or falls) is the usual etiologic factor.

**Diagnosis**—Pain, frothy, bloody expectoration and rapidly developing subcutaneous emphysema occurring in a patient subjected to recent trauma indicate the presence of a fractured trachea.

**Treatment**—The mortality which was formerly very high has been lessened by prompt tracheotomy and proper drainage produced by intelligent persistent use of suction. This should be followed as soon as possible by careful repair of the damaged tissues.

## FRACTURES OF RIBS, CLAVICLE AND SCAPULA\*

### FRACTURES OF THE RIBS

**Etiology and Pathology**—Fractures of the ribs (Fig. 309) occur relatively frequently and tend to be multiple. Double fractures may occur. Because of the great elasticity of the ribs in children fractures of these bones are relatively rare before the age of puberty. Ribs may be fractured by either direct or indirect violence and occasionally by muscular action, as from a cough or sneeze or from hearty laughing. In a fracture which is the result of direct violence the fragments tend to be driven inward into the pleural cavity and may not only rupture the parietal pleura but may also penetrate the visceral pleura and damage the lung. The fractures usually are complete and may be comminuted. The plane of the fracture may be transverse, oblique or irregular. The first two ribs are rarely broken because they are protected by the shoulder and clavicle and the last two are rarely broken because their distal extremity is free and can be moved widely in any direction before a fracture can occur. The majority of fractures involve the fifth to the ninth ribs.

**Diagnosis**—There is usually a history of an injury, either of a fall against some object or of a blow or crushing injury to the chest followed by a sharp pain in the side. The pain persists and the patient usually is able to localize it very exactly. If the fracture is at all severe, the patient tends to lean to the affected side and to support and immobilize the area of the fracture with his hands. Deep breathing causes sharp pain in the chest. There may or may not be localized swelling and evidences of contusion and lacerations of the skin. The patient should first be asked to localize with his fingers the points of greatest pain. Then the surgeon should place one hand on the back of the chest well away from the painful area and the other hand on the front of the chest and gently compress the chest by springing the anterior extremity of the ribs inward. If there is a fracture this maneuver will elicit sharp pain at the site. Anteroposterior and

\* This section contains quotations from Key and Conwell's textbook entitled *Management of Fractures, Dislocations and Sprains*, ed. 3, St. Louis: C. V. Mosby Co., 1912.

lateral roentgenograms will generally reveal the fracture (Fig 309). Even if the x-ray picture shows no abnormality the patient should be treated for fractured rib if the clinical observations indicate that a fracture is present. A stethoscopic examination of the chest should be made to determine whether or not there has been pleural or lung injury.

**Complications.** The complications are (1) massive collapse of the lung (2) pneumothorax (3) interstitial or surgical emphysema (4) hemothorax (5) hemorrhage into the lung (6) empyema (7) traumatic asphyxia or cyanosis and (8) paralytic

a severely crushed chest is always grave during the first few days after the injury.

**Treatment.**—In cases of severe injuries of the chest with multiple fractures of the ribs the general condition of the patient should be considered first and surgical shock should be combated. The patient improves faster is more comfortable and breathes easier if kept in a sitting or semisitting position. Sufficient morphine should be given to keep him quiet. External heat should be applied in sufficient amounts to bring the body temperature to normal.

If extensive multiple fractures of the ribs are present and the side of the chest is caved

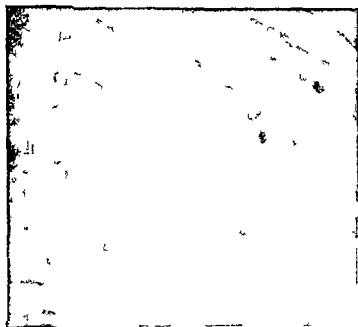


Fig 309—Roentgenogram showing fractures of the four lower ribs. Usually this type of fracture can be treated with a simple horizontal strapping.

**Prognosis.**—Fracture of a rib practically always heals despite the fact that it is not possible to immobilize the fragments. If the fragments are displaced healing takes place with deformity and not infrequently synostosis may occur between two or more ribs. In spite of the deformity the functional result is practically always good. The general prognosis depends on the severity of the injury including any complications which may arise and the general condition of the patient. In older persons the prognosis is less favorable than in the young because the former are more apt to succumb to respiratory infections. The prognosis in the case of

in strapping with adhesive tape is usually to be avoided since it serves to increase the pain and respiratory distress. It is always a good rule to remove the strapping immediately if the patient is not more comfortable and if the general condition is not better after the adhesive tape has been applied. In such cases no dressing at all or a heavy muslin swathe or elastic stockinet bandage may be used.

Most patients with a simple or minor multiple fracture of the ribs are more comfortable and do better if the chest is strapped (Fig 310). This is particularly true of fractures below the fourth rib. In fractures of

the upper four ribs, healing progresses almost as well without strapping, and sometimes the patient is more comfortable. In certain fractures of the upper ribs, vertical strapping over the shoulder and down the

old tape should, if possible, be left on for ten days or two weeks, since early removal and reapplication not only cause pain and discomfort to the patient, but also result in increased irritation of the skin. At the end

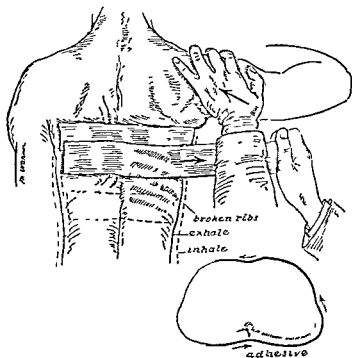


Fig 310—Strapping ribs. When the skin is tender it is better to bandage the entire chest tightly in exhalation \*

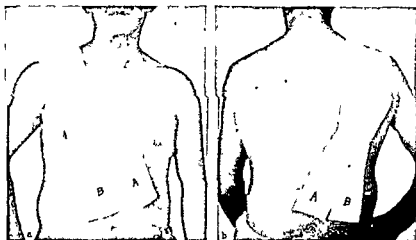


Fig 311—Front and back views (a and b) showing the vertical method of strapping for fractures of the upper four ribs †

back may be of distinct advantage to the patient's comfort (Fig. 311).

At the end of four or five days, if the chest has been strapped, the adhesive tape will have become loose and rather inefficient. It should be reinforced by fresh tape over the old, applied in the same manner. The

of ten days or two weeks it will probably be necessary to remove the tape. This should not, however, be done until it is necessary

\* Christopher—Minor Surgery, W. B. Saunders Co., Publishers

† Key and Conwell—The Management of Fractures, Dislocations and Sprains, C. V. Mosby Co., Publishers



New adhesive tape should be applied in the same manner after the skin has been washed with alcohol and ether. At the end of from fourteen to eighteen days strapping will in most cases not be necessary since the ribs will be fairly well immobilized by callus and the patient will be more comfortable without them. In obese women with large pendulous breasts it is usually best to hold up the breasts with a tight brassiere or muslin binder.

#### TRACTIONS OF THE COSTAL CARTILAGES

Fractures of the costal cartilages tend to occur more frequently in young adults while fractures of ribs occur more frequently in persons over thirty years of age. One or more ribs may be separated from their articulation

or attempted reduction the chest should be strapped by cross strapping of adhesive tape.

#### TRACTIONS OF THE STERNUM

Fracture of the sternum is a rare injury. It may occur as a result of direct violence as in blows on the front of the chest from crushing injuries or from hyperflexion injuries such as result in compression fractures of the spine.

**Pathology.**—The majority of the fractures occur in the body of the bone (gladiolus) near its junction with the manubrium. The line of fracture is usually transverse, but it may be oblique while vertical fractures are almost unknown. When displacement occurs the lower fragment is usually



Fig. 312.—Roentgenogram showing typical deformity in a fracture of the middle third of the clavicle.

at the costochondral junctions the cartilage may be dislocated from its attachment to the sternum or it may be broken across at any point or two cartilages may be separated from one another. The symptoms are similar to those of a fracture of the rib except that the localizing symptoms point to a lesion in the area occupied by the costal cartilage. The lesion may not be visible in the x-ray picture.

If there is obvious dislocation with deformity attempts may be made to reduce the dislocation or displacement. The patient inspires fully while the shoulders are drawn backward by assistants and the surgeon manipulates the displaced cartilage and by direct pressure attempts to restore the normal contour of the chest. After the reduction

displaced forward and its upper end overrides the lower end of the upper fragment.

**Diagnosis.**—There is a history of injury to the chest with pain localized over the sternum. A moderate amount of swelling is present, and if displacement has occurred the swelling may be considerable. The patient tends to droop the head and shoulders forward; respiration is shallow and deep respiration and coughing or sneezing are accompanied by intense pain at the site of the fracture. On palpation it may be possible to feel the displaced fragments and determine the displacement. Mobility of the fragments may be observed during breathing. If a fracture of the sternum without displacement is suspected the diagnosis can be confirmed by an x-ray picture which should be taken.

in the lateral plane. It will show any displacement as well as the line of fracture.

**Prognosis.**—The prognosis is good since these fractures are through cancellous bone

front of the chest over the sternum. This position should be maintained for from two to three weeks, at the end of which time the patient may get up with a cross strapping

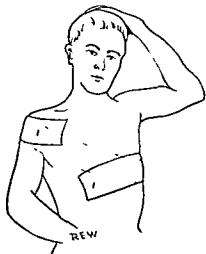


Fig 313—Adhesive dressing for fracture of the clavicle Application of adhesive strip 1 This pulls the shoulder back, aiding approximation of overlapped fragments The hand of the uninvolved side should remain on top of the head throughout the whole period of the application of the dressing \*

and tend to heal rapidly. Even if the fracture heals with overlapping, the functional prognosis is good, although there may be some visible deformity on the front of the chest.

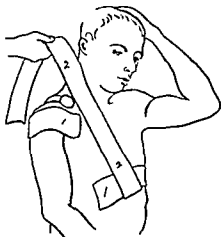


Fig 314—Adhesive dressing for fracture of the clavicle Felt pad and adhesive strip 2 being applied This procedure prevents an exaggerated upward displacement of the proximal fragment \*

**Treatment.**—If there is no displacement of the fragments, the patient should simply be placed in bed with a small pillow under his shoulders and a small sand bag on the

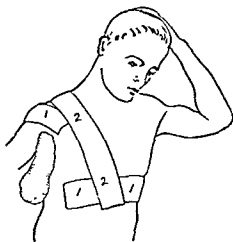


Fig. 315—The cotton prevents coaptation of the skin surfaces and acts as a fulcrum to the arm and strip 4 in relieving any overlapping of the fragments.\*

over a felt pad above the site of the fracture and a posterior figure of 8 bandage on the shoulder.

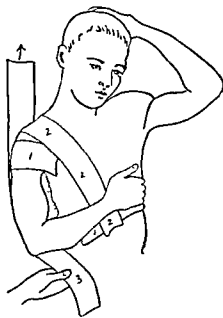


Fig 316—Adhesive dressing for fracture of the clavicle Adhesive strip 3 being applied This raises the arm and shoulder, thereby aiding further approximation of the downward misplaced distal fragment Cotton should always be applied underneath the elbow \*

When displacement and overriding of the fragments are present, an attempt should be made to reduce the displacement. This is

\* Conwell JAMA. 50.

most satisfactorily accomplished if the patient is placed in a position of hyperextension.

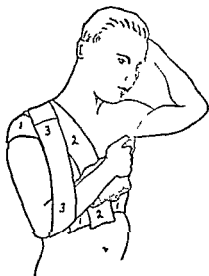


Fig 317—Adhesive dressing for fracture of the clavicle. Adhesive strip 3 applied.\*

sion involving particularly the cervical and upper thoracic spine. The arms should be placed above the head and the shoulders



Fig 318—Adhesive dressing for fracture of the clavicle. Adhesive strip 1 crossing the back obliquely around to the front of the chest from the uninvolved side of the back and axilla. The termination of adhesive strip 2 and the commencement of adhesive strip 4 are shown. The latter crosses horizontally across the back, then across the lower third of the arm on the involved side and then around in front across the forearm (see Fig 319). The posterior application of strip 3 is also shown.\*

drawn backward. If necessary, traction should be used with countertraction on the feet.

With the patient in this position, the surgeon should attempt by downward pressure on the upper end of the lower fragment to push it backward into its normal position. If this is very painful the fractured area may be anesthetized by infiltration with novocain. If it is found to be impossible to reduce the displacement by the closed method, the fracture may be exposed (preferably under local anesthesia) and the depressed fragment levered up into place, but this is not always necessary for a good functional result. The after-treatment is the same as that described for fractures of ribs.

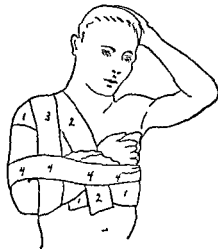


Fig 319—Adhesive dressing for fracture of the clavicle. The completed dressing showing the elbow flexed with the forearm against the chest and adhesive strip 4 horizontally crossing the arm and forearm ending at the point where it commenced. Cotton should always be placed between the skin surface and the adhesive strips and the forearm.\*

#### FRACTURES OF THE CLAVICLE

**Etiology.**—The clavicle is one of the most frequently broken bones in the body, and statistics show that it is involved in from 5 to 10 per cent of all fractures. This is especially true in childhood, when many of the fractures are incomplete and are often not recognized. The injury usually occurs as a result of a fall on the outstretched hand, elbow or shoulder, the latter being pushed violently inward against the chest.

**Pathology.**—The clavicle may be broken in any part. In the majority of cases the break occurs in the middle third just internal to the attachment of the coracoid ligament (Fig 312). In adults the fracture line

is usually oblique but it may vary from transverse to almost longitudinal and may take almost any direction. In older persons the bone is often comminuted. Complete fracture of the bone results in shortening with overriding of the fragments the shoulder drops downward forward and inward and the outer fragment goes with the shoulder. The sternomastoid muscle tends to pull the inner fragment upward and backward but its displacement is limited by the costo-clavicular ligament. When the outer third of the clavicle is fractured the lesion is usually a transverse break and as the outer fragment is fixed to the acromion and the inner fragment is bound to the coracoid there is little displacement unless this ligament is ruptured but the scapula may swing forward and cause an angular deformity at the site of the fracture.

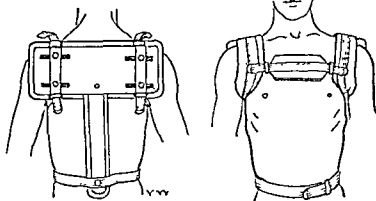


Fig 320—Zimmer clavicular cross

**Diagnosis**—The patient assumes a characteristic attitude with the limb on the affected side supported by the other hand the head is inclined to the affected side with the chin rotated to the opposite side to release the tension of the sternomastoid muscle on the inner fragment. On inspection the shoulder is found to be normal in contour but it is lower than the one on the other side slightly closer to the midline of the body and displaced slightly forward. On palpation tenderness is noted over the site of the fracture and it is frequently possible to feel the prominent outer end of the inner fragment beneath the skin. In fractures without overriding or displacement the history of injury followed by disability in the arm and the location of the pain and point tenderness are usually sufficient to establish a diagnosis.

In children with incomplete fractures there may be no displacement and the history may be indefinite it simply having been noted by the parents that the child complained of pain or cried when lifted by the arm and did not use the arm normally. The shoulder may be normal to inspection but the child will usually be unable to raise the affected arm above the level of the shoulder and point tenderness may be elicited at the site of the fracture. There may be slight swelling over the fracture and the diagnosis can be confirmed by roentgenograms or some days later by the presence of a small amount of callus at the site of the fracture.

**Treatment**—The object of treatment is to obtain a satisfactory functional and cosmetic result to make the patient comfortable and to restrict his activity as little as necessary. In greenstick fractures in chil-

dren the clavicle is bowed forward and since the deformity tends to persist it should be corrected. This can be accomplished with the patient in the recumbent position by pressing backward at the apex of the deformity. A general anesthetic is administered and the deformity is corrected. Conwell's dressing (Figs 313-319) the modified Velpeur dressing or the posterior figure of 8 bandage is simple comfortable and adequate and will suffice as a dressing in these cases.

In fractures with slight displacement in patients of any age except those who are quite fat or very old and feeble the adhesive dressing of Conwell is as comfortable and efficient as any. It should be worn for from three to five weeks followed by a sling for two weeks. The clavicular cross (Fig 320) is favored by many competent surgeons for

this type of case, but it is difficult to make comfortable if it is applied tightly enough to be efficient. In cases of fracture in fit or senile patients the axillary pad swathe and sling are useful. This dressing is not very efficient but it can be made fairly comfortable and gives a good function if and usually a good cosmetic result. It should be worn for from three to five weeks followed by a sling for two weeks. In fractures with marked displacement in any type of patient or fractures with mild or moderate displacement in young girls or women in whom a good cosmetic result is of importance removal by with lateral traction is the method of choice.

**Treatment**—As there is little tendency for the fragment to be displaced all that is necessary is to make the patient as comfortable as possible until the bone has healed. This is accomplished by immobilizing the shoulder and the soft parts over the scapula with an adequate criss cross strapping with adhesive tape over the scapula by fastening the arm to the chest with a pad placed in the axilla and by employing a sling for the wrist. Function is gradually resumed about four weeks after the injury and complete recovery is usually obtained.

**B Fractures of the Spine of the Scapula**—These fractures are practically always

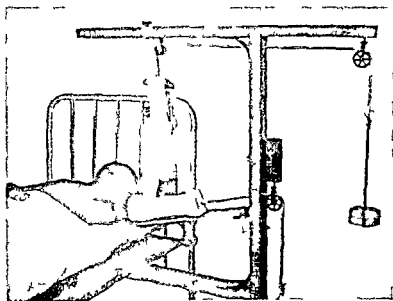


Fig. 321.—Connell's lateral traction frame for treating fractures of the clavicle, sternum, scapula and upper extremity when traction on the bed is indicated.

(Fig. 321) This will reduce practically any displacement and assure an almost perfect result in almost every case.

### FRACTURES OF THE SCAPULA

**A Fractures of the Body**—Diagnosis is made from the history of an injury either directly over the bone or indirectly from force transmitted through the humerus followed by local pain, swelling, tenderness and usually an inability to raise the arm fully on the affected side. There is tenderness over the scapula. Fracture of the scapula may be overlooked or ignored because of the gravity of other injuries and the accompanying shock, surgical emphysema or pneumothorax.

the result of direct violence and are usually accompanied by a comminuted fracture of the body of the scapula. The diagnosis is established by the local tenderness and swelling with a palpable change in contour and the ability to detect loose fragments or false motion. There is little tendency to displacement but false motion and crepitus may be elicited.

**Treatment**—In these injuries also there is little or no tendency to displacement of the fragments and they are treated exactly as are fractures of the body of the bone.

**C Fractures of the Acromion**—By careful palpation along the outer portion of the spine the fracture line can be felt as an irregularity in the bone or located by the

presence of point tenderness. False motion may be obtained by manipulating the acromion or by pushing upward on the humerus while the scapula is fixed. When the fracture is lateral to the acromioclavicular joint there is little tendency for displacement of the small free fragment and a diagnosis must be based on the point tenderness and the ability to produce false motion of the tip of the acromion. Usually the small detached fragment cannot be palpated and an x-ray examination is necessary before the diagnosis is made.

**Treatment**—In fractures through the base without displacement and in those instances in which the fracture line lies lateral to the acromioclavicular joint the tip of the process

arm is abducted or actively adducted against resistance. False motion and crepitus can not always be obtained.

**Treatment**—A convenient and efficient method of treatment is to place a pad of saddlers felt 3 inches in diameter and 1/2 inches thick over the fractured process. This is held in place by a strip of adhesive tape 3 inches wide which is started on the posterolateral aspect of the shoulder and pulled forward and downward across the pad and fastened around the opposite side of the chest. After the axilla is padded and the chest protected by a circular bandage the hand on the affected side is then placed on the opposite shoulder and immobilized in the third and fourth strips of Conwell's ad-



Fig. 323—Roentgenogram showing a separation of the acromioclavicular articulation.

being detached a cross cross strapping should be applied over the deltoid muscle in such a manner that the adhesive tape which is pulled from below upward tends to force the fragment back in place. The arm is then immobilized by a circular swathe and sling as in fractures of the body. In fractures through the base of the acromion or through the acromioclavicular joint with flattening of the shoulder and dropping down of the detached fragment the condition is similar to an acromioclavicular lesion and the acromioclavicular adhesive dressing should be applied.

**D Fractures of the Coracoid Process**—The symptoms are swelling and tenderness over the process and localized pain when the

adhesive dressing or in a Velpau bandage. This dressing is worn for about three weeks and then the arm is carried in a sling for two weeks longer.

**F Fractures of the Surgical Neck and Glenoid Cavity**—**Diagnosis**—In a typical case of fracture of the neck of the scapula with tearing of the ligaments and marked displacement the lesion somewhat resembles that of a dislocation of the shoulder except that there is no fixation of the upper extremity. There is total inability to use the arm. Passive motion is not restricted by means of a push upward on the elbow the deformity can be reduced and crepitus may be obtained.

In fractures of the neck or glenoid in

which the ligaments remain intact the *diagnosis* is more difficult. Swelling and tenderness of the shoulder and prominence of the acromion are noted. In a fracture of the neck of the scapula if the inferior angle and body of the bone is grasped with one hand and the upper end of the humerus and coracoid process with the other false motion and crepitus may be demonstrated by manipulating one part of the bone while the other is immobilized. Fractures of the glenoid are to be suspected when pain and crepitus are elicited on slight rotation of the humerus. An x ray picture should always be taken if possible in cases of injury to the shoulder.



Fig. 323.—Type of ambulatory dressing which is useful for treatment of acromioclavicular separations.\*

**Treatment**—In simple fractures through the neck of the scapula with relatively little damage to the ligaments with only slight downward displacement of the shoulder joint and with no involvement of the glenoid cavity a most satisfactory method of treatment is a slight modification of the acromioclavicular adhesive dressing. In fractures of the neck with considerable damage to the ligaments and downward displacement of the shoulder but no damage to the glenoid cavity an adhesive dressing should be tried but the results should be carefully checked

by x ray pictures and if the position of the fragments is not satisfactory the patient should be treated in recumbency with lateral traction. If the fracture line involves the glenoid cavity and if comminution and separation of the fragments are present the fracture must be treated with traction and with the arm in abduction preferably with the patient recumbent. The traction tends to pull the fragments of the glenoid cavity back into position and hold them there.

**Prognosis**—In fractures of the neck which do not involve the glenoid cavity a normal condition of the shoulder may be expected in three months unless there is severe damage to the soft parts and traumatic arthritis or periarthritis develops. These may prolong the disability indefinitely.

In fractures of the glenoid cavity without displacement a practically normal shoulder is usually obtained. If the bone is comminuted there is apt to be more or less limitation of motion together with occasional twinges of pain from time to time especially during changes of weather.

H. FARLEY CONWELL

## TRACTURES OF THE UPPER ARM

Success in the treatment of a fracture of the upper arm is largely dependent on the following considerations:

1. A careful yet rapid preliminary examination of the patient must be made in order to ascertain not only the location and extent of the fracture of the upper extremity but the degree of injury to the soft tissues, the signs of associated pathologic conditions elsewhere and the presence or absence of shock.

2. The surgeon must be able to evaluate quickly the importance of these physical findings and considering the patient's age, occupation and social status to decide how strenuous an effort should be made to bring about an accurate alignment of the broken bone and whether in the attainment of this end conservative or radical (operative) methods of treatment should be employed.

3. In the reduction of the fracture it must be borne in mind that the position of the bone fragments is dependent on two factors: the direction and degree of the force causing the injury and the effect of pull on the mus-

\* Key and Conwell: The Management of Fractures, Dislocations and Sprains. C. V. Mosby Co., Philadelphia.

humerus (Fig 323 C) is occasionally met with in a child or young adult, and it has been emphasized by Howard and Eloesser that in the second decade of life it is particularly prone to occur because at that period the epiphyseal line is the weakest point in the upper third of the bone. The mechanism of its production is similar to that for fracture through the surgical neck (Fig 323 D) and the clinical manifestations seldom allow a differentiation to be made without the aid of an x-ray picture. In the treatment it must be remembered that accurate anatomical contact is of paramount importance because one is dealing with the epiphysis which unites it and an incomplete reduction may result in a noticeable disturbance in the growth of the bone. If the condition is treated early enough this is usually accomplished without much difficulty by traction under anesthesia with direct pressure on the upper end of the long fragment and during the maneuver one may actually feel the upper end of the shaft slip back into place. Once the separation is properly reduced and checked with the x-ray picture the natural convexity of the under surface of the epiphysis tend to prevent any chance of position during the rather brief period of bone repair (from four to six weeks with the arm abducted in a plaster cast or Thomas splint). Abduction may be necessary to maintain the position of the fragments.

**B Fracture through the surgical neck** of the humerus the portion of the bone between the tuberosities and the attachment of the pectoralis major muscle assume a role of major importance because of their great frequency and the difficulties that sometimes accompany their treatment. They are seen in children and young adults particularly rarely in those of advanced years. In the report of a series of 500 consecutive fractures of the humerus published by Cubbins and

the long distal one being pulled inward by the strong action of the pectoralis major latissimus dorsi and teres major and upward by the long head of the triceps and coracobrachialis muscles. Clinically one observes great swelling just below the shoulder and deviation inward of the axis of the arm crepitation on movement of the shaft and failure of rotation of the head of the bone. Not infrequently the upper end of the lower fragment can be palpated with the fingers in the axilla.

As to the treatment in these cases a great deal of controversy has arisen as to the proper course to pursue. Böhler and most other surgeons take the stand that reduction can be satisfactorily made by abduction of the arm to 45 degrees and traction in the line of the upper arm this position being maintained during the necessary period of bone repair (from eight to twelve weeks) either by a properly applied aeroplane splint if the patient is ambulatory or a Thomas splint with adhesive tape traction if the patient is kept in bed. Howard and Eloesser on the other hand after a long series of experiments with fractures artificially produced on the cadaver and as a result of wide clinical experience take the position that the short upper bone fragment in these injuries is scarcely abducted at all because of the splinting action of the long tendon of the biceps (when intact) and the untorn portion of the periosteum (Fig 324 C and D). The use of local anesthesia reduction by downward traction in line with the upper fragment and immobilization by means of an ambulatory type of splint with the upper arm close to the body has been very successful in their hands. The abducted position of the arm has one great advantage namely that it relaxes the great muscles about the shoulder and preserves the position that is the most difficult to regain after the arm has been close to the side for a long

period. Fractures of the shaft of the humerus comprising about one half of all fractures of the upper arm offer many interesting problems because of the wide variation in pathology, the likelihood of involvement of the musculospiral nerve and the ability of delayed or non union. Direct rather than indirect violence is respon-



portion of the capsule of the joint. There is severe bruising of the muscles, great effusion of blood over a large area and consequently much swelling about the shoulder and upper arm. The treatment in such a case presents a major problem and often taxes the ability and judgment of the surgeon. Though Bohler has stated that he has been almost uniformly successful in the reduction of the head by manipulation under local anesthetic, most surgeons feel that without open operation it is rarely possible to overcome this displacement of the head and bring about satisfactory contact through the frac-

ture line. A blow and occasionally it is pulled loose by severe muscle violence. The signs of injury are manifest by local tenderness and swelling beneath the acromion process in the axilla. The patient is unable to rotate the upper arm outwardly and sometimes by actual palpation of the displaced fragment. The diagnosis must be verified by x-ray pictures taken at the proper angle (Fig. 323, A). The treatment of these injuries has for its object an accurate contact of the broken surfaces in order to preserve the function of rotation, prevent excessive callus formation and obviate a permanently painful

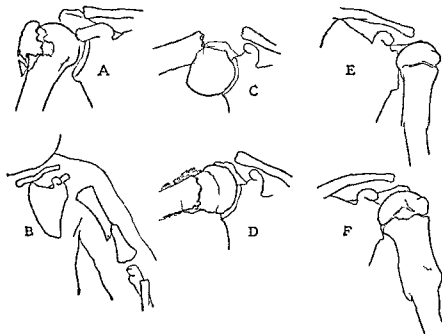


Fig. 323.—Drawings made from x-ray films. A Unusually good example of an isolated fracture of the greater tuberosity. B fracture of the humerus at birth. C and D fracture through the surgical neck just beyond the epiphyseal line in a boy of ten years. Open reduction was obtained after satisfactory alignment by means of manipulation. E and F pathological fracture through a bone cyst in a young girl at the forearm site—the upper third of the humerus.

ture line. The alignment of the bone, however secured, must be maintained with the arm in the abducted position either by means of a plaster cast or a suitable traction apparatus for a period of from eight to twelve weeks. A gradual change in the angle of abduction and the early use of active motion will do much to preserve the range of mobility at the shoulder joint.

Its success is largely dependent therefore on the absence of an associated dislocation because if a dislocation is present the correct position of the arm during the period of bone repair (abduction and external rotation) is not favorable for healing of a tear in the inferior portion of the joint capsule and must be modified to meet these conditions. In rare instances in which very accurate function of the shoulder is of great importance (i.e., of a baseball pitcher) open operation may be indicated after conservative measures have failed.

#### 4 Separation of the upper epiphysis of the

cles which insert on the proximal and distal fragments. One would be wise in observing the cardinal principle that the fragment which can be controlled (distal) must be placed and maintained in line with and in contact with if possible the fragment over which the surgeon can have little or perhaps no control (proximal).

4 In the effort to accomplish this objective the trauma will be minimized if the patient is seen early before the swelling of the soft parts has made palpation of the bony landmarks difficult. Moreover the type of apparatus to be employed for traction and immobilization must be determined in the light of the patient's age, his general condi-

tuberosities without much gross displacement are very frequently seen. They occur particularly in elderly persons with brittle bones and are the result of a slight fall on either the elbow or the arm in the abducted position. There is considerable swelling about the shoulder pain on movement and local tenderness on palpation. Because of the frequent impaction the head is apt to rotate with the shaft and no crepitation may be felt. Conservatism in treatment is the wise policy as the bone will readily unite and fair use of the shoulder may be preserved if a simple sling is worn or if the arm is abducted for two or three weeks in a comfortable aeroplane spine. I have used the

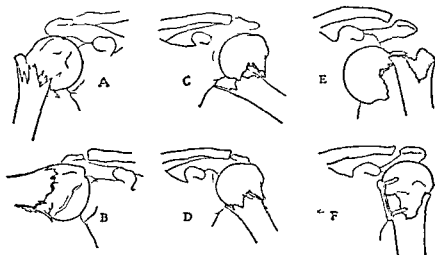


Fig 324—Drawings made from x-ray films. A and B Fracture through the surgical neck brought into excellent alignment by rather marked abduction of the arm and the use of a Thomas splint. C and D fracture through the surgical neck with little abduction of the upper fragment. Good alignment was obtained with the arm in moderate abduction. E and F example of a rare injury, severe fracture-dislocation at the upper end of the humerus. Good reduction and alignment were secured with the application of a short Lane plate.

tion and the extent of bruising or laceration of the soft parts, the surgeon keeping in mind the necessity for the preservation of the patient's general health and the use of active motion of the extremity as early as is consistent with safety.

5 And lastly important as is the selection of the proper type of apparatus, it is surpassed in importance by the manner in which the apparatus is applied and the daily attention paid to it by the attending surgeon.

A Fractures of the upper end of the humerus present themselves clinically in one of four ways:

1 Fractures through the head and anatomical neck into the cancellous area of the

wide elastic tetra bandage in conjunction with the sling and have found it most satisfactory. It is very important that this bandage and sling be removed once each week so that the skin can be carefully washed with soap and water and all crevices powdered with talc. Active movements at the shoulder and elbow are begun very early.

2 Severe fracture dislocations of the upper end of the bone are rare accidents occurring as a rule in strong laboring men as a result of a fall from a height on the abducted arm (Fig 324 F and I). The head of the bone may be sheared off cleanly across the anatomical neck by impingement against the lower margin of the glenoid (Speed) as it is driven through the tear in the inferior

portion of the capsule of the joint. There is severe bruising of the muscles, great effusion of blood over a large area and consequently much swelling about the shoulder and upper arm. The treatment in such a case presents a major problem and often tries the ability and judgment of the surgeon. Though Bohler has stated that he has been almost uniformly successful in the reduction of the head by manipulation under local anesthetic, most surgeons feel that without open operation it is rarely possible to overcome this displacement of the head and bring about satisfactory contact through the frac-

ture line and occasionally it is pulled loose by severe muscle violence. The signs of injury are manifest by local tenderness and swelling beneath the acromion process, inability of the patient to rotate the upper arm outwardly and sometimes by actual palpation of the displaced fragment. The diagnosis must be verified by x-ray pictures taken at the proper angle (Fig. 325 A). The treatment of these injuries has for its object an accurate contact of the broken surfaces in order to preserve the function of rotation, prevent excessive callus formation and obviate a permanently painful

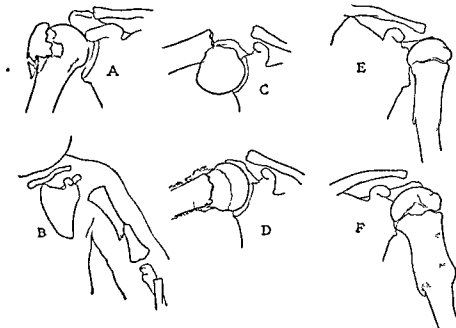


Fig. 325—Drawings made from x-ray films. A Unusually good example of an isolated fracture of the greater tuberosity. B fracture of the humerus at birth. C and D fracture through the surgical neck just beyond the epiphyseal line in a boy of ten years. Open reduction and alignment after failure of satisfactory alignment by means of manipulation. E and F pathologic fracture through a bone cyst in a young girl at the lower end of the humerus.

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3 The greater tuberosity of the humerus forming the bony prominence of the shoulder may be broken off in several ways. It occurs usually during a dislocation of the joint, sometimes it is chipped off by a glanc-

shoulder. Its success is largely dependent therefore on the absence of an associated dislocation because if a dislocation is present the correct position of the arm during the period of bone repair (abduction and external rotation) is not favorable for healing of a tear in the inferior portion of the joint capsule and must be modified to meet these conditions. In rare instances in which very accurate function of the shoulder is of great importance (i.e. of a baseball pitcher) open operation may be indicated after conservative measures have failed.

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humerus (Fig 325 C) is occasionally met with in a child or young adult and it has been emphasized by Howard and Lloesser that in the second decade of life it is particularly prone to occur because at that period the epiphyseal line is the weakest point in the upper third of the bone. The mechanism of its production is similar to that for fracture through the surgical neck (Fig 325 D) and the clinical manifestations seldom allow a differentiation to be made without the aid of an x-ray picture. In the treatment it must be remembered that accurate anatomical contact is of paramount importance because one is dealing with the epiphysis which unites last and an incomplete reduction may result in a noticeable disturbance in the growth of the bone. If the condition is treated early enough this is usually accomplished without much difficulty by traction under anesthesia with direct pressure on the upper end of the long fragment and during the maneuver one may actually feel the upper end of the shaft slip back into place. Once the separation is properly reduced and checked with the x-ray picture the natural convexity of the under surface of the epiphysis tends to prevent any change of position during the rather brief period of bone repair (from four to six weeks with the arm abducted in a plaster cast or Thomas splint). Abduction may be necessary to maintain the position of the fragments.

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the long distal one being pulled inward by the strong action of the pectoralis major latissimus dorsi and teres major and upward by the long head of the triceps and coracobrachialis muscles. Clinically one observes great swelling just below the shoulder a deviation inward of the axis of the arm crepitation on movement of the shaft and failure of rotation of the head of the bone. Not infrequently the upper end of the lower fragment can be palpated with the fingers in the axilla.

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**C Fractures of the shaft of the humerus** comprising about one half of all fractures of the upper arm offer many interesting problems because of the wide variation in pathology the likelihood of involvement of the musculospiral nerve and the possibility of delayed or non union. Direct force rather than indirect violence is respon-

sible for most fractures through the shaft. The fracture may be simple or compound, transverse, oblique, spiral or comminuted. The soft parts may be intact or badly torn, and often many pieces of lead are present. It must not be forgotten, also, that the shaft of the bone is a favorite site for bone cyst (Fig. 325, E and F), metastatic carcinoma (Fig. 326, C), sarcoma and osteomyelitis, and any one of these may predispose to the so-called "spontaneous fracture" by very little force. The degree of displacement is determined largely by the amount of comminution, the direction of the breaking force and the effect of muscle pull but a rather

traying exactly the fracture line and the degree of comminution. Of greatest importance is the evidence of concomitant injury of the neighboring large vessels and nerves, and it cannot be too strongly emphasized that in the preliminary examination of the extremity, note must be made of the presence or absence of wrist drop, for if this is first observed after reduction has been made, an embarrassing controversy may arise as to the cause of its production. The musculospiral nerve hugs the bone very closely as it passes spirally along the middle third of the bone (Fig. 327) and may be bruised or torn by the force of impact, by the sharp edges of

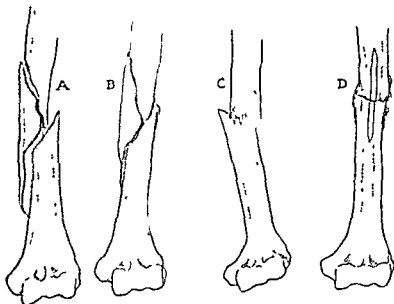


Fig. 326.—Drawings made from x ray films A and B, Spiral fracture in a girl of twenty-six years, injured by a fall while skating, showing partial involvement of the musculospiral nerve. Good alignment was obtained by traction in a Thomas splint. C pathologic fracture through the middle third at the site of metastasis from a hypernephroma in a woman aged forty-eight. D, intermedullary bone graft from the tibia in a case of non-union from the interposition of soft parts.

typical dislocation of fragments usually presents itself, depending on whether the break is above or below the insertion of the deltoid muscle. In the former instance, the proximal fragment will be drawn toward the body by the pectoralis major, latissimus dorsi and teres major; in the latter instance it will be directed outward by the strong abducting force of the deltoid muscle. Abnormal mobility is usually outspoken, and there is crepitation unless interposition of soft parts exists.

The diagnosis of these injuries is very easy, because the deformity is evident and the roentgenogram is only of value in por-

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The treatment of fractures of the shaft

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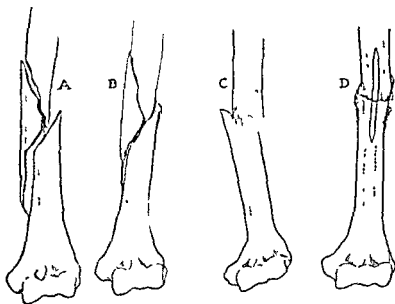


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The treatment of fractures of the shaft

involves such a variety of problems that only the basic principles can be presented here. Many surgeons like Bohler are satisfied to reduce and immobilize most of these fractures whatever their level with the arm

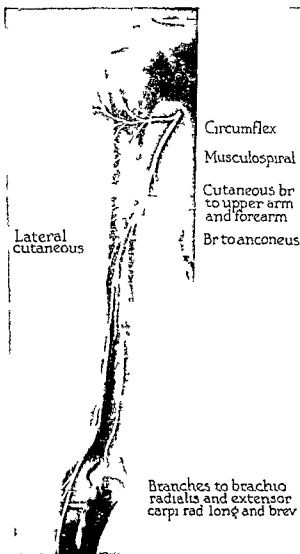


Fig. 327—Anterior view of the right arm showing the relationship of the axillary and musculospiral nerves to the humerus. From this drawing it may be readily seen how the axillary nerve and with it the circumflex vessels may be injured in association with dislocations at the shoulder and fractures of the surgical neck. The musculospiral nerve because of its close proximity to the shaft in its middle third is particularly prone to injury when there is a fracture in this portion of the bone and to inclusion in callus during the period of bone repair.

in the abducted position taking pains to prevent inward rotation of the distal fragment and to make free use whenever possible of the ambulatory aeroplane type of splint. Others prefer to leave the arm close

to the side taking advantage of the natural adducted position of the upper fragment and the traction effect of the weight of the arm in this position. For children we have made frequent use of the same type of skeletal traction for fractures of the shaft as for the common fractures in the supracondylar area. This is illustrated in figure 328. The degree of abduction can be readily changed to meet all conditions. Very severe injuries particularly the compound fractures with extensive laceration of the soft parts are unquestionably best treated after debridement with the patient in the recumbent position.

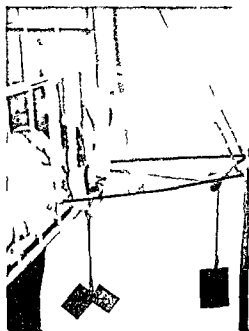


Fig. 328—Skeletal traction by means of a small screw in the ulna just distal to the olecranon process.

sition making use of the Thomas splint or the extension apparatus of Bardenheuer with moderate abduction of the upper arm combined with right angle flexion of the forearm. Ambulatory treatment in any case follows naturally as soon as the repair of the bone permits active motion of the shoulder and elbow. Those fractures through the lower third of the bone where the shaft broadens out to meet the condyles are best handled with the patient up and about with the upper arm close to the body, the elbow flexed to a right angle and the forearm in strong pronation (Bohler).

One of the most common and distressing



where the humerus takes a distinct forward bend. The fracture line does not enter the joint (Fig 332).

**Etiology**—This fracture occurs predominantly in children. About four fifths of them occur in children under ten years of age and nine tenths in persons under twenty. There are two varieties of this fracture. The classical one is the "extension" type. It occurs

ment being displaced backward and upward usually with internal rotation. The distal end of the upper fragment is felt as a prom-

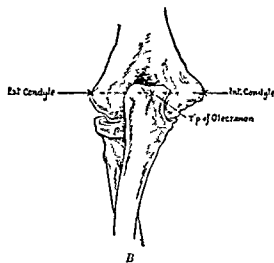
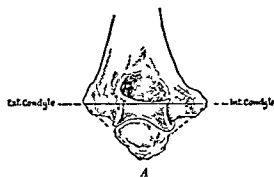


Fig 330.—Posterior views of the bones of the elbow joint. *A* In right angled flexion. *B* In full normal extension. Note that in extension the tip of the olecranon approaches the internal condyle.\*

as the result of a fall on the outstretched hand. The more unusual or "flexion" type occurs as the result of a fall on the flexed

arm beneath the biceps tendon. The forearm looks short and flexion is limited. Swelling and bleb formation are marked.

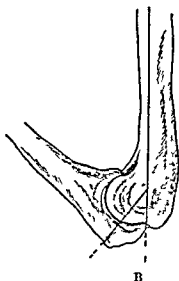
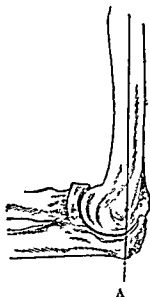


Fig 331.—Diagram showing the relation of the bony points of the elbow. *A* Right angled position. *B* acutely flexed position. Note the relative position of the condyle and the tip of the olecranon in each.\*

elbow. This fracture is most often seen in adults, as children usually fall on the outstretched hand rather than on the elbow.

**Diagnosis**—In the "extension" type the line of fracture passes obliquely from behind downward and forward, the distal frag-

ment is anterior, the forearm looks long and extension at the elbow is limited. The line of fracture is oblique from in front downward.

\* L'Esan: Fractures of the Humerus, Radius and Ulna. D. Appleton Century Co., Publishers.

and backward. Impaction is rare, and any lateral displacement is of the lower fragment outward. If the fracture is compound, the

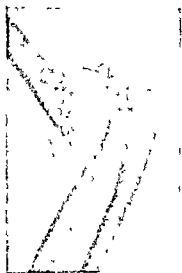


Fig 332—Supracondylar fracture of the humerus in a child. Note the typical deformity and the soft tissue thickening through the elbow. This is the "extension" or common type.

wound is made by the lower end of the upper fragment.

Dislocation is ruled out by the normal relation of the bony landmarks and the imp-

of the head of the radius or posterior dislocation at the elbow. Nerve injury may be present.

**Diacondylar Fractures.**—The etiology of these fractures is similar to that of supracondylar fractures, but the fracture line is slightly lower. They are not so notably confined to childhood as the supracondylar type and are only about one fifth as common. The line of fracture is above the epiphyseal line passing through the coronoid and olecranon fossae, and is partially intra-articular. The swelling is thus greater than in supracondylar fractures. In general, the complications are similar to those encountered in supracondylar fractures.

**Intercondylar, T or Y Fractures (Condylar).**—Whereas the above mentioned fractures are most common in children, the atypical or T or Y fractures are seen mostly in adults. They occur infrequently.

**Etiology.**—These conditions are usually the result of severe trauma from a fall on the flexed elbow, forcing the olecranon between the condyles, which then break loose from the shaft. The comminution is pronounced when caused by a crushing force.

**Diagnosis.**—Usually great swelling, discoloration and deformity (shapeless elbow)



Fig 333—T or Y fracture involving the condyles. This fracture usually results from a fall on the elbow, most often in adults.

ness of the arm. In dislocation the forearm is held in rigid semiflexion. These fractures are occasionally complicated by other injuries around the elbow, especially fracture

are noted, with mobility of the condyles on each other and on the shaft. Impaction does not exist. Crepitus is present unless joint swelling or interposition of soft parts pre-

vents The distance between the condyles is increased The diagnosis is made definitely only by means of roentgenograms (Fig 333)

**Fractures of the condyles** are almost as common as the supracondylar fractures The external condyle is more often fractured than the internal condyle In external condylar fractures the fragment usually includes the external condyle the external epicondyle and the capitellum the line of fracture extending upward and outward from the trochlea The fragment in internal condylar fractures includes also as a rule the trochlea and the internal epicondyle The typical line of fracture runs from the lateral side of the trochlea upward and inward above the internal epicondyle

**Etiology**—Fracture of the external condyle may be produced by a fall on the outstretched hand the force passing through the radius to the capitellum by a fall on the flexed and abducted elbow the olecranon being forced against the capitellum or by direct force The internal condyle is typically fractured by a fall on the adducted and flexed elbow the olecranon being forced against the trochlea It may also be fractured by direct force Children usually fall on the outstretched hand rather than the elbow and thus suffer external rather than internal condylar fractures

**Diagnosis**—In external condylar fractures greater pain and swelling on the outer aspect of the elbow are noted The external condyle is movable with crepitus if swelling is not too great It has lost its normal relationship to the olecranon and internal condyle Flexion and supination of the forearm is limited and painful The condition may be complicated by rotation of the fragment so that the capitellum looks upward and not forward These fractures being due to the same type of injury as supracondylar and discondylar fractures are subject to the same type of complications

In internal condylar fractures the pain and swelling are greater on the inner aspect of the elbow Because of the loss of support of the internal condyle the forearm swings inward losing its carrying angle and its relationship to the shaft and olecranon is destroyed Action of the pronator and superficial flexor muscles of the forearm is limited

and painful There may be injury to the ulnar nerve This fracture may be complicated by fracture of the olecranon

**Fractures of the Epicondyles**—Fracture of either epicondyle is rare but that of the internal epicondyle is more common than that of the external epicondyle The internal one is frequently associated with posterior dislocation at the elbow

**Diagnosis**—Fractures of the epicondyles when uncomplicated are of no great moment Fractures of the internal epicondyle do not enter the joint while those of the external epicondyle may do so In the e fractures localized pain tenderness swelling mobility and crepitus are noted In the fractures of the external epicondyle there is painful flexion and supination of the forearm due to muscle attachment With the internal epicondyle action of the pronator and superficial flexor muscles of the forearm is limited and painful The fragment of either epicondyle will be displaced downward by muscle pull The possibility must be borne in mind of mistaking for a fracture the normally persisting epiphyseal line as seen in the roentgenogram

Fracture of the internal epicondyle is not infrequently complicated by injury to the ulnar nerve because of its close relation hip

**Fractures of the capitellum** are rare and occur as the result of indirect force on the capitellum through the head of the radius The fracture is entirely intra articular and is similar in etiology and symptoms to a fracture of the head of the radius except that the head of the radius moves with the shaft The diagnosis is usually made roentgenographically

**Fractures of the Trochlea**—This is an extremely rare fracture It occurs as a result of indirect force on the trochlea through the ulna This fracture like that of the capitellum is intra articular and hence associated with joint symptoms chiefly swelling tenderness and pain together with joint effusion and limitation of motion Here also the diagnosis is usually made by roentgenogram

**Epiphyseal Separations of Lower End of Humerus**—At birth the entire shaft of the humerus is ossified while the two extremities are cartilaginous There are four or more nuclei of ossification in the lower extremity which appear as follows (Fig 334)

*Lower Epiphysis*

- 1 Nucleus for capitellum and part of side of trochlea
- 2 Nucleus for internal epicondyle
- 3 Nucleus for trochlea There may be more than one
- 4 A very small and insignificant nucleus for the external epicondyle

*Date of Appearance**Date of Union*

At end of 1st year

16th to 17th year

During 5th year

10th year

During 10th year

16th to 17th year

During 13th to 14th year

16th year

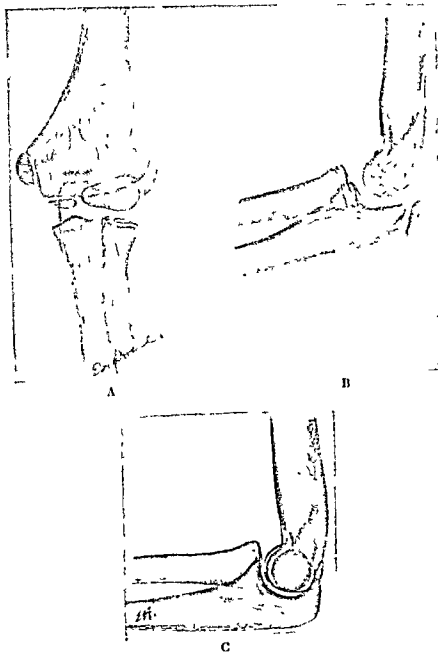


Fig 334—A, The anterior-posterior view shows the epiphysal centers for the capitellum, the trochlea, the internal epicondyle, and the external epicondyle for the lower end of the humerus and the center for the head of the radius. B, The lateral view shows the center for the head of the radius and the olecranon center. C, Note the three concentric circles, the largest and smallest being the trochlea and the intermediate one, the capitellum. This appearance indicates a true lateral view.

Thus the lower end of the humerus lacks a single common epiphysis similar to those of other long bones. Instead ossification pro-

ceeds from several distinct epiphysal centers which unite with the shaft at different age periods. Any of these epiphyses may be-

come separated as a result of trauma during the vulnerable period.

Up to the age of ten, about one fifth of the growth of the humerus is believed to come from the lower epiphysis. After this time there is little growth from this epiphysis; hence its separation has little effect on the length of the bone.

Separation of the entire lower humeral epiphysis is rare but possible up to the age of four or five. It is really a cartilage separation of the entire end containing the four developing centers. With respect to etiology,

internal epicondylar epiphysis remains separate and unites with the shaft during the nineteenth year. This would indicate that between the ages of thirteen and seventeen the three lateral epiphyses separate as a group. It does not mean, however, that this cannot occur before the age of thirteen, as the majority of such injuries are found in children less than thirteen years of age.

Cotton states that at about thirteen years a trochlear ossification occurs which unites to the shaft soon after and thus explains the occasional separation in one group of the

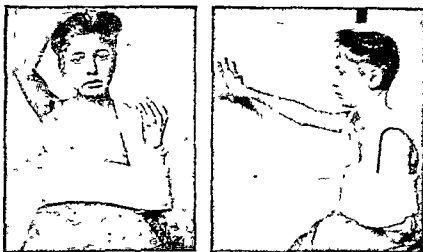


Fig 335—Eliason's lateral hyperflexion position and dressing. The plaster to support the wrist was omitted for photographic purposes.

mechanism, symptoms and deformity, it does not differ from a supracondylar fracture except that the lesion is seen to be lower in the roentgenogram.

These various epiphyseal centers may be separated individually until they fuse with one another.

**Epiphyseal Separation of External Condyle.**—This term is used to denote the three lateral epiphyseal centers, namely, the external epicondyle, the capitellum and the trochlea. Some writers consider that these centers comprise the lower humeral epiphysis since they commonly separate as a group, leaving the internal epicondyle intact (Scudder). This is one of the most common injuries of the lower end of the humerus. It is the consensus of opinion that the three lateral epiphyseal centers unite to form a single bony epiphysis during the thirteenth year, which fuses with the shaft in the sixteenth to seventeenth year. The

external condyle, capitellum and a small portion of the trochlea but not the entire trochlea.

The joint capsule is attached above the epiphyseal line so as to enclose all but the internal epicondyle. Epiphyseal separations, therefore, are intra-articular; so unless the capsular ligament is torn, it tends to prevent any great displacement.

**Epiphyseal Separation of the Internal Epicondyle.**—The internal epicondylar epiphysis is formed from a separate ossification center which is displaced internally by the downward growth of the diaphysis, so that by the thirteenth year it is a distinct detached epiphyseal particle not communicating with the joint. It fuses with the shaft during the nineteenth year.

Separation of the internal epicondyle occurs more often than that of the external epicondyle, since the latter usually separates with the capitellum and trochlea as

mentioned previously. The mechanism diagnosis and treatment are the same as in fracture of the internal epicondyle.

As with fractures of the internal epicondyle epiphyseal separations are frequently associated with posterior dislocation of the elbow. There is occasionally injury to the ulnar nerve.

**Treatment of Fractures of the Lower Extremity of the Humerus.**—These fractures should be reduced under general anesthesia with the aid of a fluoroscope at the earliest possible moment. Proper reduction is the quickest means of reducing the swelling. The supracondylar and dicondylar fractures and separation of the entire lower humeral epiphysis simulate posterior dislocation of the elbow as to deformity and may be reduced in a similar manner. Traction is made on the forearm in the partially flexed position and counter pressure is made over the anterior surface of the lower end of the upper fragment. While this combined traction is maintained, the forearm is completely flexed carrying the supinated hand to the shoulder on the same side with the humerus against the side. In this lateral hyperflexed position the arm may be fixed in plaster.

Several turns of plaster of paris bandages are applied (the skin being protected) reaching from the axilla to the condyles. This is allowed to harden no rotation being allowed meanwhile. The limb is then placed so that the humerus lies on the plane of the patient's back. A swathe of appropriate width and long enough to encompass the trunk three times is made of several reduplications of plaster of paris bandage on a strip of lint or sheet wadding. With one end applied to the posterior aspect of the sound axilla the swathe is carried diagonally across the back over the shoulder around the affected forearm and humerus back to the place of starting where it passes over the first end and continues around the front of the chest again to envelop the forearm and arm. The swathe should not be reversed as it comes over the shoulder and diagonally around the wrist and forearm. Turns of plaster bandage can be added to give further stability one or two being carried around the hand as far as the metacarpophalangeal joints for support to the wrist and the prevention of an awkward droop.

If the forearm is flexed too acutely on the arm the radial pulse will be cut off. It is imperative therefore that the arm be watched carefully for two or three days since slight increased swelling may occur even after reduction and constrict the blood supply. If

such occurs the cast must be removed immediately and the forearm fixed in less acute flexion. In many instances there is a great deal of swelling by the time the patient reaches the surgeon, so that the forearm cannot be fixed acutely enough for the permanent dressing. It is preferable then to flex the arm to about a right angle, place a posterior molded plaster splint from the shoulder to the hand and maintain it in the lateral position by means of a temporary adhesive dressing. In three or four days when the swelling has sufficiently subsided, the flexion of the forearm may be increased and the permanent cast applied as described above.

In some instances fluoroscopic observation will reveal that the reduction can be satisfactorily maintained with the forearm

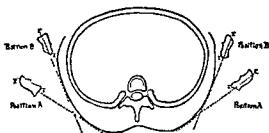


Fig. 336.—Cross section through trunk and arms at the condylar level. Position A the normal one is retained in the lateral hyperflexed position. Position B is the one assumed where the forearm rests on the chest. E and I represent the external and internal condyles respectively.\*

across the chest on an internal right angle splint or in the anterior hyperflexed or Jones position. Such dressings are less cumbersome than the lateral hyperflexed position in a plaster cast. When the lateral hyperflexed position is used the cast may usually be removed in two or three weeks and the arm placed in the Jones position. It is then possible to remove the dressing two or three times a week and exercise the elbow within the limits of pain. At each dressing the forearm may be lowered but the ability to flex the forearm should be maintained. After the fourth week a sling will suffice for support. Complete extension is slow in returning and should not be forced. After six weeks some weight may be carried to aid extension.

In the T or Y fracture traction on the

\* Elason: Fractures of the Humerus, Elbow and Ulna. D. Appleton Century Co., Publishers.

forearm with slight elbow flexion in a Murray-Jones splint as bed treatment may be necessary. A pin or wire through the olecranon may be used at times. In certain refractory cases, open reduction may be necessary. When a fracture of the internal or external condyles cannot be satisfactorily reduced by ordinary means, an open reduction should be done. In recent years some excel-

adults. Restoration of full function may require a year. Uncorrected rotation is a frequent cause of cubitus varus (gunstock deformity). This occurs most frequently in supracondylar fractures. External condylar fractures give better ultimate flexion and extension as a rule than do internal condylar fractures. Internal condylar fractures are difficult to keep reduced and so occasion-



Fig. 337.—Jones position and dressing for many "elbow" fractures. Care should be exercised in this dressing not to rotate the lower fragment.\*

lent results have been obtained with the use of the hanging cast for fractures in the lower third of the shaft as well as in the upper two thirds.

In fractures of the capitellum or trochlea, if the fragment is free in the joint it must be removed, as it will not be absorbed. The absence of a radial pulse or the presence of nerve injury usually indicates open operation. [The editor has seen two successful closed reductions of the capitellum (Christopher, F. and Bushnell, L. F.: *J. Bone & Joint Surg.* 17:489, 1935).]

**Prognosis.**—Function is good after good reduction. The prognosis must be more guarded as to function and deformity in

ally result in non-union. Epicondylar fractures very frequently result in fibrous union but with good function.

Function is to be striven for at the expense of anatomical perfection, therefore, massage and motion must be employed. In fractures through the epiphyseal line, interference with growth may result. This does not apply after the fifteenth to sixteenth year, when growth from the lower epiphysis ceases.

The prognosis in any given case is altered by the occurrence of complications. In supracondylar, discondylar and epiphyseal

\* Roberts and Kelly. *Fractures*. J. B. Lippincott Co. Publishers.

fractures marked swelling and bleb formation may occur. The most common complication is the difficulty in preventing recurrence of the deformity. The median ulnar and more often the musculospiral nerve may be injured. It is important to recognize any such nerve injury before reduction. Definite nerve injury may be an indication for open reduction so that the nerve may be sutured if severed or freed if caught between the fragments. Ischemic muscular atrophy (Volkmann's contracture) is probably due much more to vascular interruption than to impairment of function resulting from faulty reduction. Absence of the radial pulse, pallor and coldness of the hand should be recognized early. Open operation may be required to free the artery from constriction by the bony fragment. The radial pulse will occasionally disappear when the elbow is dressed in acute flexion so that a better reduction must be accomplished or another type of dressing used. Myositis ossificans (ossified hematoma) may occur with most detrimental results on function.

## FRACTURES OF THE UPPER EXTREMITY OF THE ULNA

**Anatomy.**—The olecranon and coronoid processes form a semicircular articulating surface which fits neatly around the trochlea making a hinge joint with the humerus. Thus a force applied through the ulna, as a fall on the elbow, is passed on to the trochlea. However, the trochlea is larger on its medial side and tapers off toward the middle so that a fall on the elbow in the abducted position transmits the force against the side of the capitellum.

**Fractures of the olecranon (Fig 338)** are the fourth most common fractures involving the elbow joint (13 per cent of the total number). Fracture of the extreme tip or break occasionally occurs but the usual site of fracture is at the junction of the coronoid process and the olecranon. The epiphyseal line is small and above this site. It enters but little into the elbow joint. The tip of the olecranon before the fourteenth year prior to full development is on a plane anterior to the plane of the shaft of the humerus with the elbow in right angled flexion; hence the infrequency of olecranon fractures in youth.

**Etiology.**—These fractures are produced by direct violence as by a fall on the elbow or less frequently by muscular action as by

a fall on the semiflexed forearm. Direct violence produces a transverse fracture. Muscular action alone or with direct violence produces a transverse or oblique fracture with or without separation.

Epiphyseal separation is uncommon but is produced by the same mechanism as the fracture. The epiphysis appears during the tenth year and has joined the diaphysis by the seventeenth year.

**Diagnosis.**—In the absence of separation there is local tenderness, slight swelling and painful and limited extension. When the fracture line enters the joint as it usually does there is joint swelling and a lack of stability of the joint. Wide separation may result from extensive laceration of the triceps expansion. With separation crepitation is absent. The fragment is easily palpated and with the forearm extended it is above its normal level as compared with the opposite side. Fracture of the olecranon may be complicated by anterior dislocation of the radius and ulna or fracture of the internal condyle or the coronoid process.

**Treatment.**—As a rule there is separation of the fragments and open reduction is necessary. The fragments are approximated with chromic catgut kangaroo tendon or strips of fascia lata. Occasionally a satisfactory reduction may be maintained by extension of the forearm and looping a strip of adhesive tape around the fragment and over the forearm. If there is no separation of the fragments an internal right angle splint will suffice.

Motion is cautiously begun in two weeks. The splint is removed after union has occurred usually in five or six weeks.

The prognosis is good if approximation of the fragment has been secured. Even if separation is present fibrous union results and if the stability of the joint is not affected by the widened hinge function will be good and the union strong. Stimson mentions the fact that ankylosis has followed in a certain number of cases. The fact that this fracture enters the joint jeopardizes ultimate function especially in adults.

**Fractures of the coronoid process** are usually associated with posterior dislocation of the elbow (Fig 338).

**Etiology.**—The usual cause is a fall on the arm in flexion which results in pos-



terior dislocation of the elbow and an incidental fracture of the coronoid process. Writers have reported this fracture as being unaccompanied by posterior dislocation but this is unlikely. If a sufficiently careful history is taken in fracture cases most of the patients will be found to have had a partial dislocation that snapped back after the fracture occurred or had been reduced previous to the x-ray diagnosis. Some authors mention muscular action but this seems unlikely as many of the fractures are of the tip of the process where the brachialis anticus muscle is attached at its base. Direct violence resulting in a crush fracture may break the coronoid process.

hence union is the usual result. In the roentgenogram the view must be a direct lateral one and unless the picture is clear the fragment may not be detected.

**Treatment**—The hyperflexed or Jones position maintained for two or three weeks followed by the use of an internal right angle splint or a Bolles splint is the most satisfactory treatment. Massage and slight motion (from 10 to 15 degrees) should be started after the tenth day. All splint should be removed in five or six weeks and a sling used intermittently for fatigue. If there is no displacement the arm may be dressed from the beginning in the right angled position.



Fig. 338.—Fracture of olecranon and coronoid processes of ulna and high fracture of neck of radius. Boy age sixteen years. Fell 20 feet striking on elbow.

**Diagnosis**—Definite diagnosis without the help of a roentgenogram is virtually impossible except in cases in which a large fragment exists in a thin person who is seen before swelling occurs. Clinically one is led to suspect a coronoid fracture if a case of posterior dislocation of both bones at the elbow tends to recur easily. Tenderness and possibly a fullness in the antecubital fossa to the inner side of the biceps tendon may be found. Wide displacement is rare; the fragments usually being held as on a hinge by the periosteum, the capsular ligament and the expansion of the brachialis attachment.

**Prognosis**—Results are extremely favorable in growing children as are those in all joints. A more guarded prognosis must be given in older patients especially those with evidence of osteoarthritic changes. Osculation of the hematoma which develops in the region of the fracture may cause complete ankylosis.

**Fractures of the Upper End of the Radius**—The nucleus of the upper epiphysis of the radius appears about the fifth year and unites with the diaphysis during the six

\* E. H. Mason: Fractures of the Humerus, Radius and Ulna. D. Appleton Century Co. P. 153.

teenth year. The epiphysis includes only the upper portion of the head, the lower part and the neck being ossified from the shaft. The head is entirely intra-articular and has no ligamentous attachments.

The head of the radius articulates with the capitellum and is palpable just below the external condyle. It is most prominent in extreme pronation of the forearm. The head and the upper part of the neck are intra-articular, made so by the orbicular ligament which attaches only to the inner side of the neck.

Fractures of the head of the radius are second in number only to supracondylar fractures in statistics on fractures at the elbow joint.

**Etiology.**—The fracture is usually produced by a fall on the pronated hand with the forearm extended. The trauma is thus transmitted to the head of the radius as it is driven against the capitellum. Direct violence is another cause of this fracture.

**Diagnosis.**—The entire head may be crushed or broken off or the fracture may be simple, stellate or comminuted in almost any manner. Displacement is usually not great. There is pain, increased on motion with tenderness over the head of the radius. Crepitus is rare. If the fragment is displaced inward it completely limits flexion; if outward, it is over the external condyle and easily palpable. When there is no displacement a roentgenogram is usually required to make the diagnosis. In patients between the ages of five and seventeen this may be a separation of the epiphysis. The etiology and symptoms are the same as in cases of fracture.

**Treatment.**—In fractures without displacement the limb is dressed preferably in mid-pronation on an internal right angled splint. After ten days, gentle motion is begun. Fixation is maintained for from three to six weeks, depending on the age of the patient. If the fragments are free in the joint, they should be removed in order to obtain good function.

**Prognosis.**—If the fragments are impacted or if the longitudinal break into the neck has periosteal attachment, union will occur. If there is wide separation of the fragments,

the results are better when treated by operation (Speed, Cotton, Stimson, *et al.*). The fracture is occasionally associated with fracture of the external condyle of the humerus, dislocation of the radius, dislocation of both bones, fractures of the coronoid process and fractures of the shaft of the ulna.

Fractures of the neck of the radius are only about one fourth as common as those of the head. About half of these occur in



Fig. 339.—Fracture of the upper end of the shaft of the ulna together with anterior dislocation of the head of the radius.\*

patients under twenty years of age (Fig. 338).

**Etiology.**—This fracture, like that of the head of the radius, is usually caused by a fall on the outstretched hand, with the forearm extended and in pronation. Extreme abduction of the forearm at the elbow is said to cause it.

**Diagnosis.**—In complete fracture the upper fragment is turned outward by action of

\* Eliason: Fractures of the Humerus, Radius and Ulna. D. Appleton-Century Co. Publishers.

the supinator brevis. If the fracture is oblique it is partially extracapsular. An incomplete fracture occurs in children. Localized pain, tenderness, swelling and possibly deformity and crepitus are noted. The head does not rotate with the shaft unless the fracture is impacted or incomplete. Supination is limited and painful.

**Treatment**—When reduction under the fluoroscope is unsuccessful, excision should be performed. If the fracture can be reduced it is best dressed over molded plaster splints in full supination and with 90 degree flexion. Massage is begun on the tenth day and slight motion in two weeks. The splints are worn for from four to six weeks.

The prognosis in uncomplicated cases is good although there may be slight limitation in rotation. The fracture may be associated with other fractures in this region especially of the olecranon, coronoid process or shaft of the ulna.

**General Considerations of Fractures in and around the Elbow Joint** (1) Early reduction is usually the easiest reduction. (2) Loss of flexion is more crippling than loss of extension. (3) Loss of pronation can be compensated by an abduction of the limb; loss of supination has no compensatory factor. (4) Increased carrying angle is often followed by ulnar neuritis. (5) The prognosis should be guarded when the fracture involves the joint for the results in the form of traumatic arthritis often take years to develop. (6) Traumatic myositis ossificans or ossified hematoma occasionally occurs within the brachialis anticus muscle. (7) A loose fragment in the joint is a bad tenant.

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#### FRACTURES OF THE RADIUS AND ULNA

##### FRACTURES OF THE DISTAL END OF THE RADIUS (COLLES' FRACTURE)

**Etiology**—The cause of a Colles' fracture is almost always a fall on the outstretched hand. The type of fracture and its bony deformity depend upon the force of the fall and the position of the hand at the time of impact.

**Pathology**—The injury involves the surrounding soft parts as well as bone. The distal fragment usually is driven dorsally along with the hand and carpus so that the structures in the volar carpal canal (the flexor tendons and median nerve) are drawn against the end of the proximal bone fragment (Fig. 341). Injury to the extensor pollicis longus tendon at the fracture level followed by subsequent spontaneous rupture occasionally occurs. The radial or ulnar arteries may be compressed. The pulse and the nerve and when possible tendon function always should be tested before and after reduction of the fracture.

The triangular fibrocartilage may be torn or avulsed. If intact, abnormal tension is put upon it especially in positions of full rotation by slight residual shortening of the radius (Fig. 341). Such shortening also deranges the mechanics of the inferior radio-ulnar joint. The net result may be a painful wrist necessitating subperiosteal resection of the ulnar head for its relief. Consequently for prevention of such a late complication it is of utmost importance that the radial length be regained and maintained until bony healing occurs. Associated fractures of the ulnar styloid occur in more than 50 per cent of all Colles' lesions. They require no attention despite the fact that bony union is rare. Not uncommonly there may be an associated fracture of the radial head, carpal scaphoid, ulnar head or surgical neck of the humerus. The therapy necessary for such additional lesions may complicate or be complicated by the treatment of the Colles' fracture.

**Diagnosis**—The pathologic anatomy of

lows a fairly consistent pattern upon which the clinical diagnosis may be based. For its full comprehension four anatomic features of the normal wrist must be kept in mind (Fig 340).

(1) The radial styloid is at a level about 1 cm distal to that of the ulna making the plane of the joint such that (2) the long axis of the hand deviates ulnarwards about 10 degrees from the midline. (3) The long axis of the third metacarpal meets that of the forearm at the level of the wrist joint. (4) The dorsal surface of the wrist is flat while the ventral surface is curved concave volarwards.

across the dorsum of the radius. (3) *Radial tilt or deviation* of the distal fragment which deranges the styloid relationships and reduces or reverses the normal ulnar deviation of the hand. (4) *Radial shift or displacement* of the distal fragment which shifts the long axis of the third metacarpal radialwards and results in undue prominence of the ulnar head. (5) *Impaction* of the two fragments or *overriding* which produces shortening of the radius as estimated by the styloid levels.

A reverse Colles fracture is a relatively uncommon lesion characterized by volar displacement or angulation of the distal

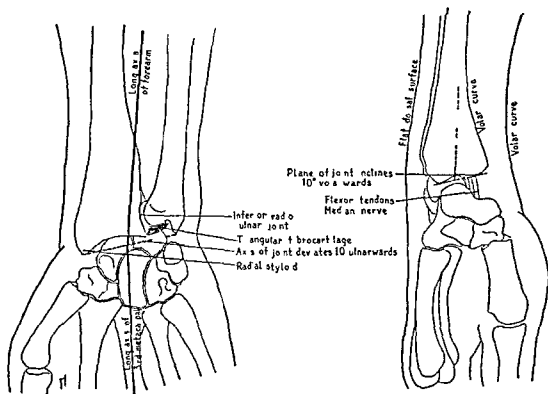


Fig 340—Diagram showing the anatomic features of the normal wrist.

A Colles fracture may be without displacement or it may be characterized by one or all or any combination of the following deformities each of which affects the anatomic features in a way that can be recognized clinically by inspection or palpation (Fig 341).

(1) *Dorsal tilt or angulation* of the distal fragment which if small reduces and if large reverses the volar curve. (2) *Dorsal shift or displacement* of the distal fragment which deranges the volar curve and produces a palpable bony ridge transversely

fragment so that the normal volar curve becomes accentuated when compared to that of the normal wrist. Some rotatory deformity frequently is present in all Colles fractures but seldom is clinically evident. In addition to the existing anatomic derangement diagnostic evidence is almost always present in the form of swelling which originates on the dorsal surface and extends circumferentially. Direct and indirect tenderness at the fracture site, pain aggravated by any motion of the wrist and frequently volar ecchymosis.

**Treatment**—Treatment should be preceded by first aid measures consisting of adequate sedation and the application of an emergency board splint and sling. Reduction is most easily accomplished under light general anesthesia. If this is contraindicated, local injection of 15 to 30 cc of 1 per cent novocain may be used with satisfactory results in the first twelve hours during which the fracture hematoma remains in a fluid state. Hematoma blood should be withdrawn into the syringe before novocain is injected. After twelve hours has passed local anesthesia becomes progressively less satisfac-

of reduction is by determination of the re-establishment of the normal anatomic characteristics of the wrist (Fig 340). Fluoroscopic facilities are of great value in the confirmation of reduction but their consistent use as an aid in reduction is unnecessary and unwise.

**Maintenance of reduction** is best accomplished by plaster splints which may be molded to both dorsal and volar surfaces of the forearm or carried around the flexed elbow with the forearm in mid rotation in the form of a sugar tongs so as to control excessive rotary motion. A circular plaster

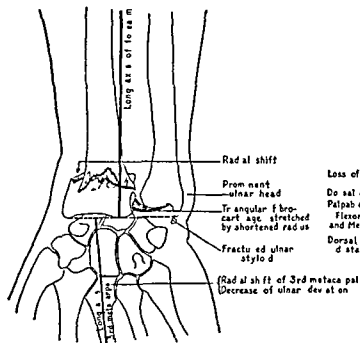


Fig 341

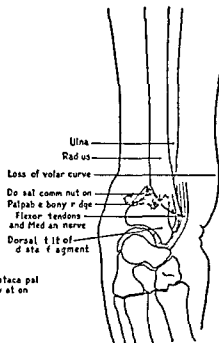


Fig 342

Fig 341.—Diagram showing the pathologic findings in a fracture of the distal end of the radius (Colles' fracture).  
Fig 342.—Lateral aspect of same fracture.

tory. If the ulnar styloid is fractured, injection of the novocain into this region also is indicated.

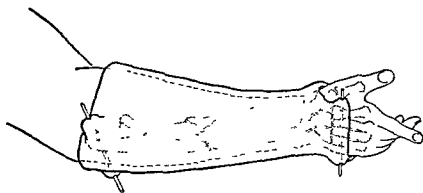
The *reduction maneuvers* depend upon the bony deformities present. Primary distal impaction should precede any attempt at reduction of an impacted fracture. All manipulations are facilitated by preliminary traction sufficient to relax the existing muscle spasm. Angulations should be corrected and displacements reduced one at a time by manipulation of the distal fragment with one hand while the proximal fragment is stabilized with the other. Clinical confirmation

of reduction is by determination of the re-establishment of the normal anatomic characteristics of the wrist (Fig 340). Fluoroscopic facilities are of great value in the confirmation of reduction but their consistent use as an aid in reduction is unnecessary and unwise.

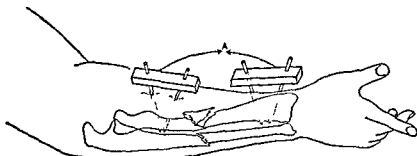
**Maintenance of reduction** is best accomplished by plaster splints which may be molded to both dorsal and volar surfaces of the forearm or carried around the flexed elbow with the forearm in mid rotation in the form of a sugar tongs so as to control excessive rotary motion. A circular plaster

sion of the dorsal tendons, ligaments and capsule, a recurrence of the deformity. In the same way, ulnar deviation usually is required for maintenance of length and correction of radialwards deformities. A reverse Colles fracture requires hyperextension. The proper amount of any such position is

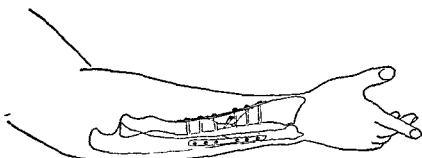
cases (Fig 341). When moderate in amount, reduction may be maintained by immobilization in a position of wrist flexion. The duration of immobilization required varies directly with the degree of comminution. Extensively comminuted fractures tend to collapse and shorten inside any type of ex-



Double Pins Incorporated in Circular Plaster



Multiple pins fixed at A by mechanical apparatus



Internal fixation by plate and screws

Fig 343—Methods of skeletal fixation in fractures of both bones of the forearm

the least amount necessary for the maintenance of reduction and can be determined only by the operator. Whenever such abnormal positions are found to be unnecessary, the hand should be placed in the grasp position of maximum function, with the wrist extended.

*Dorsal comminution* is present in many

ternal splint and can be controlled only by the additional use of two Kirschner wires, one through the olecranon and the other through one or several metacarpals (Fig. 343). During reduction, normal length may be obtained by distraction of the two wires by assistants, and following reduction, maintenance of length may be accomplished by

incorporating both wires into the immobilizing plaster so that shortening cannot occur.

**After Care**—Adequate after care demands the following precautions:

1. Frequent inspection of the circulatory status of the hand is necessary, especially during the first week. As swelling increases the splints should be rebandaged less tightly. Later as it subsides they should be tightened progressively. A comminuted lesion requiring the use of wire traction necessitates the application of a circular plaster splint; therefore the patient should be hospitalized until the circulatory status of the part returns to within the limits of safety.

2. Early and constant light use and exercise of the fingers must be insisted upon. When necessary resumption of finger function may be initiated by a set of simple exercises such as squeezing a rubber ball or sponge or apposing finger tips to thumb.

3. Maintenance of shoulder mobility should be given particular attention since the shoulder may become stiffened and painful from disuse, especially in a person past middle age.

4. Roentgen examinations are required for confirmation of reduction followed by subsequent films to determine that the position is maintained. X ray is of little or no value in estimating the time for removal of splints, since visible callus at the fracture site is small in amount and evidence of bony union by x ray is not present until weeks or months after clinical union has occurred.

The duration of immobilization depends upon the type of fracture and the amount of comminution. Undisplaced fractures and impacted lesions not requiring reduction are splinted for rest, comfort and protection rather than maintenance of position. Therefore splints should be removed for warm soaks and active wrist exercises as soon as symptoms will permit (usually within a week) and should be discarded within about two weeks or slightly longer. The average Colles fracture requires two to four weeks of splinting following reduction and the duration must be determined by the operator on a basis of the stability of the fracture at the time of reduction. The more comminuted the fracture the longer it should remain immobilized. Badly comminuted

fractures, especially those necessitating the use of wire traction, require a minimum of six weeks of immobilization. Under ordinary circumstances splints should be discarded gradually as progressive healing lessens the need for external support rather than suddenly. A leather or elastic wristlet minimizes the pain and weakness which commonly follow the final removal of all external splints.

It occasionally is unwise to aim for anatomic restoration of the bone fragments. This is particularly true in the case of elderly arthritic patients in whom the institution of immobilization sufficient to maintain the reduction of a comminuted Colles fracture may result in a permanently stiffened and painful wrist regardless of the anatomic perfection evidenced roentgenographically. Gross bony deformity does not always result in pain or disability, whereas protracted immobilization of an arthritic wrist of an elderly person is very apt to do so. In selected cases the patient should be warned of residual deformity; the wrist should be splinted for rest and comfort without any reduction and an effort should be made to maintain function rather than position by the early institution of warm soaks, active exercises and use. The usual result will be a deformed but useful and reasonably comfortable wrist.

#### EPIPHYSEAL INJURIES AT THE DISTAL RADIAL EPIPHYSIS

Epiphyseal injuries are more common at the distal end of the radius than in any other location of the body. Subsequent growth disturbance is to be expected in less than 5 per cent of such injuries. Sprain of the wrist is almost a nonentity in children and lesions that appear to be a sprain almost always are undisplaced epiphyseal injuries in which in spite of completely negative x ray evidence the risk of subsequent growth derangement is just as great as if the epiphyses were grossly displaced. The diagnosis can not be made by x ray but becomes reasonably certain if circumferential tenderness limited to the epiphyseal area persists for more than a week. The active treatment of such lesions requires nothing more than a temporary splint for comfort and protection. If it can be accomplished without force a

grossly displaced radial epiphysis deserves reduction followed by several weeks of immobilization. If reduction cannot be accomplished without undue force it is wise to immobilize the lesion in an incompletely reduced position. Forceful or repeated attempts at reduction strongly predispose to subsequent growth disturbance and open reduction almost insures it whereas most mild displacement deformities tend to be corrected by growth. The prognosis should be guarded in all epiphyseal injuries no matter how innocuous they seem at the time of treatment.

#### FRACTURES OF BOTH BONES OF THE FOREARM

**Anatomy**—The intricate muscular anatomy of the forearm must be kept in mind when dealing with fractures of both radius and ulna. It is the most important single factor to be overcome in the reduction and the subsequent maintenance of position of the fracture.

1 The radius is curved concave volarwards. This curve is essential to pronation and supination during which it is necessary for the radius to roll circumferentially around the long axis of the ulna.

2 The shafts of the radius and ulna are connected by the interosseous membrane which in fracture is seldom torn enough for the two bones to separate or over ride to any marked degree.

3 The shafts are most widely separated in the position of full supination. In full pronation they are crossed scissors like in their middle thirds.

4 When the continuity of the radius is broken distal to the insertion of the pronator teres both fragments are pulled volarwards and towards the ulna the proximal by the teres and the distal by the pronator quadratus. Unopposed pull of the quadratus also tends to pronate the distal fragment whereas the teres is neutralized by the supinator attached to the proximal fragment.

5 When the radius is fractured proximal to the insertion of the teres the distal fragment is pronated and pulled ulnarwards by unopposed action of both pronators. The proximal fragment is flexed and supinated by the unopposed action of the biceps and supinator brevis.

6 The integrity of the inferior radioulnar joint is in part dependent upon the relative lengths of the two bones.

**Pathology**—The pathologic and therapeutic importance of these anatomic features manifests itself in the following ways.

1 Any gross angulation of the radius and even a slight one if against the normal curve results in some limitation of motion. Consequently the correction of angular deformities and especially those with apex volarwards is of utmost importance.

2 Fibrosis and contracture of the interosseous membrane tend to pull the fractured shafts closer to one another. Limitation of rotation results whenever this is allowed to occur. Occasionally cross union may take place between the two fractures.

3 The optimum position for immobilization is that which maintains an adequate width of interosseous space i.e. mid position to full supination never pronation.

4 When the ends of both fragments are pulled volarwards by the pronators full supination tends to accentuate the deformity. Under these circumstances the optimum position for immobilization is the mid position.

5 When the proximal fragment is flexed and supinated the long and controllable distal fragment must be realigned to suit it because the position of the proximal fragment cannot be controlled by any external splint. This requires that both reduction and immobilization be done with the elbow flexed to a right angle and supinated fully.

6 Relative shortening of the radius produces pain in the wrist by the same mechanism as described under the pathology of a Colles fracture. It is important therefore that the relative lengths of the two bones be maintained.

**Diagnosis**—The diagnosis usually is obvious. Extensive damage limited to the sub fascial region predisposes to circulatory embarrassment and care must be taken not only to ascertain that vascular function is intact but also to make sure that any constricting dressings applied do not jeopardize it. Interposition of muscle or fascia between the bone ends is not uncommon and should be ruled out before reduction is attempted by gently demonstrating the presence of crepitus. Nerve injury is not common but



its absence should always be determined. Fragments with marked displacement may pierce and become caught in the deep fascia and may be identified by the presence of an adherent dimpling of the skin at the point where the fascia is impaled.

**Treatment**—In adults the muscles are strong and the force required to break the bones is great. Comminution is common. Because of these factors reduction and maintenance of position is extremely difficult by conservative measures. When manipulative reduction has to be done it should not be attempted except under general anesthesia. Manual traction and countertraction until all muscles are relaxed and length has been regained should precede any attempt to reappose the ends of the broken bones. Even after reduction has been accomplished in many cases there is a tendency for the fragments to angulate towards each other so that the risk of cross union becomes significant. This tendency can be overcome best by maneuvering the forearm into various positions of rotation until that which produces the optimum width of the interosseous space is found. Immobilization which of necessity must include both wrist and elbow should be instituted in this optimum position. Anatomic reposition of both fragments is important and the healing time is protracted at best. Because of the diverse muscular forces to which the fragments are subjected maintenance of position by plaster alone is not only very difficult but also inefficient and often inadequate. The use of skeletal traction in the form of Kirschner wires incorporated into the plaster serves to maintain normal length but has no control over existing rotary or displacement deformities (Fig. 443). The technical difficulties and potential complications embodied in the use of the various multiple pin fixation devices gives this method of treatment (Fig. 343) all the disadvantages and none of the advantages of open reduction except when used by an expert under ideal conditions. The treatment of choice when possible is early open reduction, rigid internal fixation, a minimum of postoperative external support and early resumption of use.

In children fractures of the forearm are commonly incomplete the so-called *greenstick* or *buckle fracture*. When such an an-

gular lesion slightly increases the normal curve of the radius no reduction is necessary. All other angulations warrant correction. Complete or even adequate reduction can be obtained and maintained only by reversing the angulation until both cortices are broken. In completing such a fracture care is required lest displacement of the fragments occur.

Complete fractures in children are subject to the same muscular forces as those in adults. Less accurate reduction is sufficient to insure a good result, however especially in younger children because in inverse proportion to the age of the patient the compensatory growth of the bone has the power to correct almost all except rotary and gross angular deformities. While anatomic reposition of fragments is optimum in the reduction of a forearm fracture in the child the minimum requirements for adequate reduction demand only eradication of rotary deformity and reestablishment of bony contact and alignment. Before end to end contact can be obtained in overriding fractures it often is necessary to angulate the fragments sharply, reappose the bone ends in the angulated position and then straighten out the angulation in the manner of a carpenter's toggle joint.

Immobilization is best accomplished by plaster splints which must include both wrist and elbow. The same rules for position during immobilization apply regardless of whether both bones or only the radius is fractured. Unlike the same fractures in the adult healing by bony union is reasonably certain within four to six weeks. Refracture is common however unless some form of external support is retained for a minimum of eight weeks especially in fractures of the proximal half of the bones.

#### FRACTURES OF THE SHAFT OF THE RADIUS

Fractures of the radial shaft without an associated fracture of the shaft of the ulna are under ordinary circumstance subject to the same anatomic pathologic and therapeutic considerations as fractures of both bones. Frequently the lesion is accompanied by a fracture of the ulnar styloid. A not uncommon lesion in the adult is a transverse or short oblique fracture through the middle or lower third of the bone. While this

lesion looks rather innocuous roentgenographically and while it is found to be easily reducible (it is seldom displaced more than a small amount, with the proximal end of the distal fragment pulled towards the ulna by the pronator quadratus) it is also found that it is virtually impossible to maintain adequate reduction delayed union (often as much as four to six months) being common. Interposition of the fibers of the pronator teres insertion is common and whenever it can be done safely open reduction is strongly indicated.

#### FRACTURES OF THE SHAFT OF THE ULNA

Fractures of the ulnar shaft uncommon. Fractures of the radius occur from direct violence. When situated in the proximal half of the bone and especially if characterized by angulation pointing volar wards or laterally it should be assumed until proved otherwise that there is an accompanying rupture of the orbicular ligament allowing an anterior dislocation of the radial head. Displacement is usually minimal in amount and the attachments of the interosseous membrane seldom allow any significant angulation except in those accompanied by dislocation of the radial head. The treatment of uncomplicated ulnar fractures requires nothing more than immobilization for three to five weeks by molded plaster with the forearm in mid rotation.

HARRISON L. McLAUGHLIN

#### FRACTURES OF THE CARPAL BONES

**Anatomy.**—The eight bones of the carpus tightly packed together bound by dorsal volar and interosseous ligaments to each other to the radius and to the metacarpus provide the basis for the support of the hand. These bones clinically and anatomic ally may be divided into two rows. The first or proximal row is comprised of the os naviculare and os lunatum and articulates proximally with the radius and distally with the second row. The second row includes the pisiform os triquetrum and os hamatum on the ulnar side, the os capitatum (the key-stone central bone) and the os multangulum minus and majus (supporting the thumb) on the radial side of the wrist. True synovial

lined joints exist irregularly between them much of the surface of the bones is cartilaginous. The attachments of the ligaments occur on rough bony areas devoid of cartilage through which a rather scant blood supply penetrates the various bodies. By arrangement of coordinated movements of the intercarpal joints the normal adult wrist is mobile yet strong partly supported by the numerous tendons passing on both dorsal and volar surfaces. It presents a range of motion approximating dorsal flexion of 45 degrees volar flexion of from 60 to 70 ulnar flexion of 10 and radial flexion of 20 degrees. During these movements the axis and position of the two bones of the proximal row change yet the bones remain bound to each other to the radius and to the distal row of carpal bones but on account of this mobility and axis shifting they are the seat of most of the fractures and dislocations of the carpal area.

Carpal fractures represent about 15 per cent of all fractures of the skeleton with a higher proportion in military service they may seriously influence the use of the hand and if imperfectly healed result in diminution of the patient's wage-earning power with functional loss. Fractures of the navicular dislocation of the lunate and dislocations around the lunate bone is the order of occurrence. The latter group presents a severe type of injury often accompanied by fractures of the navicular radius and ulna or other carpal bones sometimes leaving the lunate in normal relationship with the radius. Fractures and extremely uncommon dislocations of the remaining carpal bones may occur. Unfortunately the greater mobility of and frequency of injury in the two bones of the proximal row are coupled with their relatively scant and precarious blood supply obtained largely through ligamentous attachment. Fractures and dislocations in this row therefore may be expected to require prolonged immobilization in order to insure the restoration of the blood supply maintenance of vitality healing and restoration of function.

**Etiology.**—The two mechanisms causing these lesions are direct and indirect violence, the former acting less often than the latter. Direct violence from a blow on the wrist by a stick or crushing mass may cause a lesion

regardless of the position or exposure of the hand at the instant of application and may consequently lead to open wounds involving tendons, nerves and blood vessels. The most common carpal lesion results from indirect violence usually received in falls on the hand, in back-fire injuries from cranking a motor or crush violence. The mechanism of fracture is similar to that of Colles' fracture, which may accompany it; each lesion must be studied in the two view roentgenogram to eliminate the other. Force transmitted through the fingers when a person falls on his hand is carried to the wrist via the metacarpal bones and meets there the force of

bowstring of the transverse carpal ligament preventing release from pressure. A similar mechanism, depending on the degree of radial, ulnar, dorsal or volar flexion in which the hand and wrist meet the emergency, results in the other carpal lesions; the lunate bone may become the central point of the application of the violence, or the ligaments binding it to the capitate or wrist may be torn off to permit it to be forced out of joint, just like a pit squeezed out of a cherry. The surrounding bones may be pushed away from it into dislocations, either dorsal or volar, carrying the navicular bone *en masse* with them. Often the navicular bone, on ac-

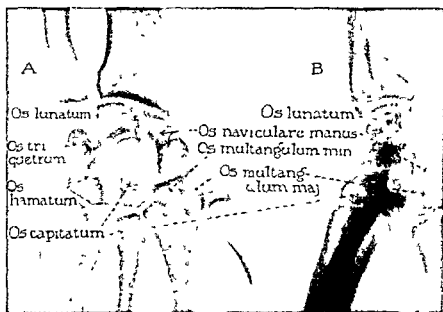


Fig 314—Arrow points to a typical transverse fracture of the navicular with little separation of fragments. In the posteroanterior view (A), no abnormal over-riding of the shadow of the carpal bones is seen. Study of the lateral view (B) demonstrates the outlines of the lunate, navicular and capitate in normal position without dislocation.

the superimposed falling body transmitted down the forearm in the person's attempt to catch himself and save a more serious injury. The violence may act by crushing the carpal bones, nearly always those of the proximal row, against the radius, or by a combination of compression and an overextension or flexion of the wrist may crack across the navicular, which is compelled to accommodate itself by changed axis and rotation to the exaggerated position while under powerful compression. This effort may cause the bone to be caught between two forces and cracked like a nut contained in an arch-like arrangement, with the strong

count of the position of the hand and wrist. is broken across, the proximal fragment bound by ligaments to the lunate remaining with it, while the distal fragment goes along with the rest of the carpal bones into dislocation around the lunate. These are the complicated perilunar dislocations, for more detailed description and illustration of which one is referred to the writer's monograph on injuries of the carpus.

carpi radialis which may become the seat of traumatic synovitis. Most of the fractures are intra articular, the synovial fluid becomes blood tinged and swelling and edema of the wrist region and its tendons and coverings follow. Interference with function is mainly a reaction to the pain of movement or the effect of grasping.

The bone involved taking the navicular as the most common may be cracked across the middle or near the proximal third may be crushed rarely comminuted or may sustain a fracture of its tuberosity. Displacement of any bone fragment is not great although dislocation combined with lesions of neighboring carpal forearm or metacarpal bones may be found. The tearing away of the ligaments may avulse small chip like fragments from the bone surface but its most untoward result is the interference with the blood supply of the bone. Unless there is immediate immobilization this deprivation of nutrition may lead to aseptic necrosis of the part of the bone involved (usually the proximal fragment but often both fragments) although the distal portion of the navicular bone receives an accessory source of vascularization through its tubercle which lies completely extra articular with excellent ligamentous attachment. At first the crack into the bone may be so faint that it is overlooked in the x ray examination made immediately but as loss of nourishment and necrosis progress the fracture plane develops and becomes more apparent in the roentgenogram and the density of the bone as a whole when viewed in the film appears greater than that of the surrounding bones which rapidly lose shadow casting calcium salts as a result of atrophy of disuse. In some instances of Sudeck's atrophy the density contrast may become astonishing in one week. Additional changes consist of extension of bone necrosis in the body of the bone and efforts at absorption and replacement which are exceedingly slow with ligamentous thickening and new bone reaction on adjacent surfaces of the radius. Ultimately the cancellous portion of the bone may die and an absorptive process may lead to cavity formation and fragmentation of the bone the cartilaginous covering surviving the longest. In some instances the history of the primary trauma being forgot

ten a condition of traumatic osteomalacia is thought to be present. When this concerns the lunate bone original fracture may be denied the condition being called Kienbock's disease a term introduced by the writer some years after Kienbock's original description. When the condition is found in the navicular bone it is often called Preiser's disease. The further the disintegration of the bone advances usually the greater the pain and stiffness in the carpus although some persons reach a resting stage from five to ten years after fracture when the distress may decrease somewhat.

**Symptomatology**—The symptoms of carpal fracture or fracture dislocation are primarily pain and partial interference with the function of the wrist and hand but not complete loss by any means. A worker may fail to report a wrist injury which has caused fracture. He may consider the lesion a sprain and be confirmed in this opinion by a physician who fails to make a careful roentgenologic examination. Local tenderness over the wrist bone involved curtailment of the normal range of wrist joint excursions as compared with that of the normal hand swelling and pain on pressure in the tabatiere (which may be obliterated by the swelling) when the navicular is involved or in the wrist bone after percussion of the head of the middle metatarsal bone complete the clinical findings. The roentgenogram is absolutely necessary to complete the diagnosis. The film should show the two wrists taken at the same angle in two axes. The character of the fracture as a faint plane across the bone's narrow axis a crushing or a fracture of the tuberosity of the navicular for example then becomes apparent. Definite roentgen ray findings in fracture of the lunate bone may be quite delayed. A careful study of the roentgenograms to determine the anatomical position of the carpal bones is required to eliminate dislocation which may be present.

**Treatment** of carpal fractures and dislocations depends on the bone involved and the complexity of the lesion. For fractures of the tuberosity of the navicular bone no splint or immobilization of the wrist is required. Slightly guarded use not causing pain will result in bony union. For all other uncomplicated fractures of the navicular,

lunate and other carpal bones immediate and prolonged immobilization is necessary. With the hand held straight the hand, wrist and forearm should be put in a plaster of paris encasement which is light, meagerly padded and close fitting and encloses the thumb in a position of slight abduction extending to the base of the fingers and at least two thirds of the way up the forearm. For navicular and lunate fractures this immobilization must last for eight weeks and then roentgenologic examination must convince the surgeon that bony union has been secured; otherwise the dressing must be re-applied and an examination made after six or eight weeks of further immobilization to determine the character of the union. Surgical removal of one or both fragments of the navicular bone immediately after the fracture has occurred should never be performed. Immobilization of fractures of the distal row may require only five to six weeks.

*Fracture dislocations* call for reduction under anesthesia accomplished by traction on the fingers, hyperextension and local pressure on the displaced lunate or other bones to push them back into place. This is followed by plaster immobilization for from four to twelve weeks depending on the bone involved.

Old fractures or fracture dislocations may be treated by surgical means. When a lunate bone has been dislocated out of position for more than a week it usually has undergone considerable change in nutrition or has suffered fracture not visible in the roentgenogram. It may be reduced by manipulation or open operation but the reduction is no guarantee that the bone will return to full health. Progress of bone changes must be studied every few months by x-ray plates. Many old dislocations do best with excision of the fractured or displaced bones, each case studied on its own merits.

Ancient fractures of the navicular bone without fragment dislocation may be treated in several ways, the most tedious but often most successful being a return to immobilization in plaster. The length of time required to obtain union may be from three to ten months but may be hoped for up to one year. If economic conditions do not warrant wearing a plaster dressing this length of time, shorter methods can be adopted such

as excision of the whole bone leaving no fragments behind and causing no injuries to neighboring bones by rough handling. Use is started as soon as the soft parts heal. This treatment is advisable for Kienbock's disease of the lunate bone but the condition may yield to a trial of prolonged immobilization with roentgenographic control.

Other operative procedures include efforts to secure bony union by a direct attack on the bone itself. The best of these is simple boring through the fragment with a  $\frac{5}{16}$  inch drill or by implanting in a hole thus made a small transplant of autogenous bone followed by three months immobilization in plaster. For non union of the fractures of the distal row sometimes accompanied by subluxation arthrodesis of the adjacent carpal joints gives relief from pain and good function. The radiocarpal joint should never thus be stiffened. Excellent functional results have been obtained by these methods.

The prognosis of carpal fractures depends on their early recognition and treatment by immobilization. The prognosis of fracture-dislocations is grave; their recognition is difficult and their treatment usually requires expert advice. The ancient cases can be much improved by a well planned and executed surgical attack.

KELLOGG SPEED

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## FRACTURES OF THE METACARPALS AND PHALANGES

Fractures of the metacarpals and phalanges are the most common fractures in the skeletal system. Their importance to any one who lives by handicraft should not be underestimated. The distal portion of the hand is most liable to injury. Our study of 1323 fractures involving the bones of the hand showed the following distributions:

	Cases	Per Cent
Distal phalanx	800	60
Middle phalanx	221	1
Proximal phalanx	189	14
Metacarpals	91	7

**Movements of the Fingers**—Two separate series of movements occur in relation to the articulations of the fingers: flexion and extension (at the metacarpophalangeal and interphalangeal joints) and abduction and adduction (only at the metacarpophalangeal joints). The movements and the muscles concerned are given in the following tables:

*Flexion*

Flexor digitorum sublimis  
 Flexor digitorum profundus  
 Lumbricales } Acting on the metacarpophalangeal and  
 Interossei } articulations  
 Flexor digiti quinti revis

*Abduction*

Flexor brevis and Opponens digiti quinti } From the medial side of the  
 Dorsal interossei } From the middle line of the middle finger

Flexion is more powerful and complete than extension of the fingers. The flexor digitorum profundus alone acts on the terminal phalanges; the flexor sublimis and the flexor profundus together flex the proximal interphalangeal joint. Flexion of the metacarpophalangeal joint is affected by these muscles as aided by the interossei, lumbricales and flexor digiti quinti brevis. Extension of the phalanges is brought about by the united action of the extensors of the digits—the interossei and lumbricales. Extension of the fingers at the metacarpophalangeal joints is produced solely by the long extensor muscles. Separate extension of the index finger only is possible; the three inner fingers can be extended together completely only because of the connecting bands joining the extensor tendons on the back of the hand.

The arrangement of the interossei and lumbrical muscles and the insertions of the flexor and extensor tendons are illustrated in figure 315.

**Fractures of the Distal Phalanx**—The terminal phalanx is attached only at its proximal end to the middle phalanx. Its

distal portion is free and not subject to the action of either the intrinsic or extrinsic muscles. It is here that considerable crushing of fragments may occur with but slight displacement. Fractures involving the proximal portion of the terminal phalanx are subject to the action of the flexor profundus tendon and the extensor communis tendon. A fracture here may develop a varying degree of dorsal displacement of the proximal fragment. Occasionally the entire proximal fragment may be evulsed. In tendon avulsions the flexor or extensor tendon may take with it its bony insertion. The treatment of fractures of the distal portion usually requires simple immobilization. Occasionally molding of the crushed fragments may be required. Fractures of the proximal portion require such immobilization as will approximate the fragments. Complete evulsion of the entire proximal fragment usually requires open reduction. Dorsal displacement

*Extension*

Extensor digitorum communis  
 Extensor indicis proprius  
 Extensor digiti quinti proprius  
 Lumbricales } Acting on the interphalangeal articulations

*Adduction*

Volar interossei—To the middle line of the middle finger

of the proximal fragment requires hyperextension and flexor tendon avulsion requires hyperflexion. Usually immobilization for one week is sufficient in crushing injuries of the distal portion. In avulsions of tendons and fractures near the proximal end an immobilization of two weeks is necessary.

Fractures of the middle phalanx owe their displacements to the action of the flexor digitorum sublimis. This muscle ends in a tendon which divides into two portions. They insert one on each side of the middle phalanx at approximately the mid portion. The deformity produced will depend on the location of the fracture site. If this site is distal to the insertion of the tendon, there occurs flexion of the proximal fragment and dorsal displacement of the distal fragment. When the fracture site is proximal to the tendon insertion, there is produced flexion

displacement of the distal fragment with the proximal fragment in an extended position Figure 345 demonstrates these points

be obtained by bringing the distal fragment into line by the use of a curved splint restoring the fragments to the natural arc

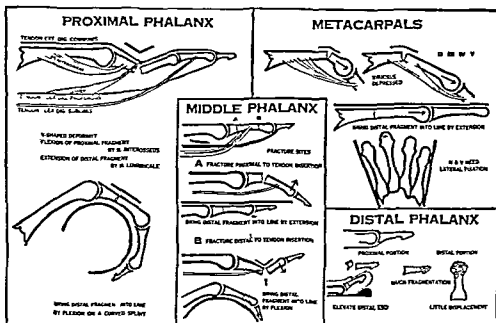


Fig 345—Fractures of the metacarpals and the phalanges

Failure to take into account these two types of displacement of fragments will result in a failure to correct the deformity

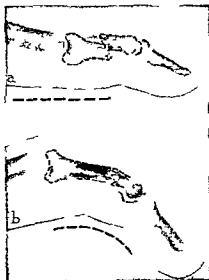


Fig 346—*a* Volar spur resulting from fixation of fractured middle phalanx on a straight splint *b* restoration of normal curvature on a curved splint

There results most commonly a palmar projecting spur which interferes with flexion of the distal phalanx (Fig 346)

In the second type adequate fixation can

which was present before the fracture took place

**Fractures of the Proximal Phalanx—**  
The resulting deformity when fracture of the proximal phalanx occurs is fairly constant regardless of the site of fracture (Fig 345). As can be seen in the accompanying illustration palmar displacement of the proximal



Fig 347—Fracture of metacarpal bone showing flexed position with dorsal projecting spur

mal fragment is brought about by the action of the interosseous muscle while dorsal displacement of the distal fragment is due to the action of the lumbrical muscle. Here again fixation on a straight splint will maintain the deformity and result in impaired function. When the distal fragment is brought into line with the proximal frag

ment by fixation on a curved splint a minimum of deformity will result

Fractures of the metacarpals (exclusive of the thumb) usually result in typical deformities characterized by shortening of the length of the bone due to bowing of the fragments. There is a dorsal projection at the site of fracture and volar displacement of the metacarpal head (Fig. 347). This deformity is the result of the action of the interosseous muscle which is a flexor of the proximal phalanx. The distal fragment of the metacarpal being attached through the metacarpophalangeal joint to the proximal phalanx is drawn into a flexed position.

The treatment of these fractures requires

phalanges in contradistinction to the other metacarpals which have distal epiphyses. Its fractures may be classified as follows (Fig. 348):

- I At the base
  - (a) Intra articular
    - 1 Bennett type
    - 2 Rolando type
  - (b) Extra articular
    - 1 Transverse
    - 2 Oblique
    - 3 Complicated
- II The shaft
  - 1 Transverse
  - 2 Oblique
  - 3 Longitudinal
- III The head
  - 1 Transverse



Fig. 348—Fractures of the first metacarpal bone

immobilization on a straight dorsal splint to restore the normal horizontal contour of the dorsum of the hand. Fractures of the third and fourth metacarpals are splinted laterally by their adjacent metacarpals. The second and fifth when fractured require dorsal splinting and in addition lateral splinting.

Fractures of the first metacarpal are of importance because of the value of the thumb in the usefulness of the hand. The first metacarpal has the movements of a proximal phalanx which indeed it resembles. It has a proximal epiphysis as have the

The treatment of fractures of the first metacarpal is of importance because of the associated pathologic condition which develops. Faulty union, atrophy of the muscles of the thenar eminence and weakness of grip all contribute to the disability which may follow a simple fracture. In all of the extra-articular types fixation in a position of extreme abduction will retain the web of the first metacarpal space and permit abduction when the splint is removed.

In the Rolando type of fracture simple abduction is usually sufficient to produce an



proximation of the fragments of the bone. The prognosis in this type of fracture is better than in the Bennett type because of the absence of upward dislocation of the shaft which is usually found in the Bennett type. In this latter type special effort must be directed to overcome the pathologic displacement. In addition to the extreme abduction suggested for the other types of fracture longitudinal traction is essential if upward dislocation of the shaft has occurred. The incorporation of a wire loop in a plaster cast about the wrist has been utilized as a means of support of longitudinal traction produced by means of adhesive strips and rubber bands.

A summary of the metacarpal and phalangeal deformities with general principles of management is illustrated in figure 345. It is evident from these illustrations that the principle of aligning the mobile distal fragment with the less mobile proximal fragment is applicable to all fractures of the bones of the hand. This simplifies the essentials of treatment and relieves the surgeon of the necessity of keeping in mind the details of the mechanism involved in the various displacements.

The materials used in the maintenance of these corrected positions are those commonly used in other fractures: tongue depressors, strips of aluminum, adhesive tape and roller bandages of various sizes.

In all applications care should be taken to preserve the blood supply to the part. The necessity of frequent examinations and the avoidance of undue pressure or constriction cannot be overemphasized.

Compound fractures of the metacarpals and phalanges occur very frequently. One must decide at once in these injuries the character and extent of the damage and plan their treatment to the end that the patient will have the best functioning hand which can be salvaged. If the soft parts are greatly damaged the operative manipulation of the fracture may serve to contaminate the wounds or impair the vitality of the tissues still further. In these cases the surgeon may be compelled to restrict his activities to a thorough debridement coupled with the simplest of corrective splinting and dressing. As the patient improves a constant attempt should be made to restore the mem-

ber and its injured parts to a position which will insure ultimate usefulness.

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MAJOR MANUEL E. LICHTENSTEIN

## FRACTURES OF THE VERTEBRAL COLUMN

**Definition**—Because of major differences in importance, treatment and etiology these fractures fall into three main groups: (1) fractures of the body (centrum) including those of the laminae and the articular and spinous processes; (2) fracture-dislocation; and (3) fractures of the transverse processes. The importance of the fractures in groups 1 and 2 lies not alone in their effect on structure and function but on the circumstance that the spinal cord is contained within injury to which is so often irreparably crippling or fatal.

**Incidence**—About 6 per cent of all fractures and dislocations fall in these groups and half of these are of the transverse process. The ratio of body fractures to dislocations is approximately one to fifteen. The age incidence is greatest in the fourth and fifth decades.

**Etiology**—The immediate causes are in direct external violence and muscular action. Commonly a fall from a height, a blow from a heavy object falling on the shoulders when the spine is flexed, an automobile accident or a diving injury produces the fracture.

**Pathology**—The fractures in groups 1 and 2 result from violent hyperflexion either forward or lateral; the body of the vertebra being crushed into a wedge or saucer shaped deformity. In most instances (80 per cent) the intervertebral disk is ruptured and disorganized. Commonly one or more of the posterior bony processes are fractured. If the flexion force is then not spent, dislocation of the vertebra above occurs. The cord may be damaged either through elongation or as a result of narrowing of the lumen of the canal caused by pressure of bone or hemorrhage incident to the fracture.

In group 3 the fracture is transverse and often several processes are involved.

the posterior portion of the vertebral body is intact—approximately 90 per cent

*E Technic of Reduction of Wedge Compression Fracture of Vertebral Body* (no dislocation posterior portion of vertebral body intact)—The keynote of successful reduction is complete hyperextension of the vertebral column. By this means the compressed fragments of the crushed body are drawn into normal relation by the pull of the longitudinal ligament. The torn ends of the posterior ligaments are approximated. Anything short of complete hyperextension will fail to effect reduction. It is the last few degrees of hyperextension that actually produces reduction.

which are convenient. Among these are the suspension<sup>3</sup>, the flexible frame<sup>2</sup>, the sling traction<sup>4</sup>, the Goldthwait irons and the table methods.<sup>5</sup> The following technics represent a modification of several of these. Each fulfill the requirements of a sound method and is simple and the apparatus is within reach of all traumatic surgeons.

*Choice of Method*—The problem of reduction in the lumbar region is much easier than that in the dorsal. A three day old fracture in any region can be more easily corrected than one that has been unreduced for a week or longer. A fracture involving the posterior wall of the centrum requires powerful traction during extension if it is

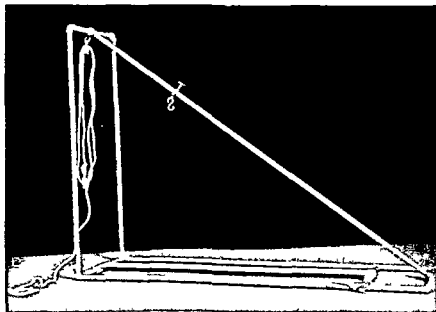


FIG. 349.—A convenient type of hammock frame. The canvas hammock is operated by means of a ratchet and pulley so that it is always under the complete control of the surgeon.

*Anesthesia*—A general anesthetic should not be used. It is dangerous and unnecessary. Morphine and scopolamine given hypodermically will produce sufficient relaxation of the muscles and will allay apprehension. The dose varies with the patient's age and weight. For an average adult  $\frac{1}{2}$  grain of morphine and  $\frac{1}{100}$  grain of scopolamine in two doses one hour apart should be satisfactory.

*Methods of Reduction*—There are a number of efficient methods of producing spinal hyperextension. Only those should be employed which are under absolute control and which do not require an anesthetic and

decided to attempt reduction so that the posterior fragments will not be pushed backward against the cord or nerve roots during reduction. The reduction of a vertebral dislocation is always dangerous and requires a special and sometimes elaborate technique. Therefore each fracture should be carefully analyzed with these points in mind and the method selected so as to meet the requirements of the individual case.

1. *Common Wedge Compression Fracture of a Lumbar or Eleventh or Twelfth Dorsal Vertebral Body (Without Cord Injury)*—No dislocation is present and the posterior wall of the body is not involved.

*The Suspension Method (Davis)*—The patient, relaxed by morphine scopolamine and with the trunk covered with stockinette is placed face down on a canvas webbing band 8 inches wide which has been drawn taut lengthwise along a fracture table or Bradford frame equipped at one end with a ratchet and pulley device as shown in figure 349. The webbing is split at the head end to provide for the patient's face. The ankles are heavily padded with sheet wadding and ankle slings are applied over this. A pulley block and tackle is fastened to the ankle slings, preferably by a spreader. The other pulley block is fixed to a point opposite the knees and high above the frame or table. The lower extremities are gradually raised by means of the block and tackle (Fig. 350). This maneuver is carried out slowly, especially at the start, to

reach the physiologic limit the fracture is thereby reduced. Thereafter the angulation can no longer be seen or felt. Occasionally, however, this may not be the case because extension seemingly carried to the limit is actually less than complete. The period of suspension should then be prolonged to overcome muscle spasm, after which gentle manipulation of the trunk from side to side while the patient is still suspended or gentle downward pressure by the surgeon's hands may be necessary to disengage impacted fragments. A plaster jacket is then applied with the patient in suspension. As quickly as this has dried the traction is released, the canvas hammock is cut and withdrawn and the patient is returned to bed.

*The Plaster Jacket*—The plaster of paris jacket (Fig. 353) is applied while the patient is on the ham-

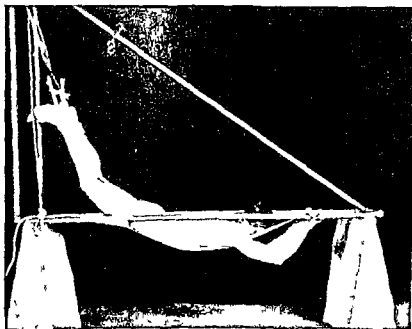


Fig. 350.—The suspension method (Davis) of obtaining spinal hyperextension combined with traction. The patient is placed face downward on the hammock. The lower extremities are gradually raised by means of the block and tackle. The surgeon is thus able to extend the spine gradually while the correcting forces are always under complete control. The felt padding may now be arranged about the torso and the jacket applied. This method is particularly indicated in fracture of a lumbar or the eleventh or twelfth dorsal vertebra.

overcome muscle spasm and with frequent pauses during which the function of the cord may be checked by having the patient move his toes. Impending pressure on the cord during reduction is heralded by motor weakness and pressure on the nerve roots is heralded by shooting pains in the lower extremities. Both are preceded by severe pain at the site of the fracture. Since a general anesthetic is not used injury to the cord during reduction can therefore be readily avoided. The limit of hyperextension is reached when the pelvis and the lower portion of the abdomen have been raised several inches above the canvas sling, the thighs make with it an angle of about 45 degrees and lumbosacral backache becomes persistent. The reduction requires but a few minutes. In order to confirm the reduction roentgenograms may then be taken while the patient is still suspended. When hyperextension has been car-

ried to the physiologic limit the fracture is thereby reduced. Thereafter the angulation can no longer be seen or felt. Occasionally, however, this may not be the case because extension seemingly carried to the limit is actually less than complete. The period of suspension should then be prolonged to overcome muscle spasm, after which gentle manipulation of the trunk from side to side while the patient is still suspended or gentle downward pressure by the surgeon's hands may be necessary to disengage impacted fragments. A plaster jacket is then applied with the patient in suspension. As quickly as this has dried the traction is released, the canvas hammock is cut and withdrawn and the patient is returned to bed.

*After Care*—The jacket should be worn for about three months. During this time the patient's weight

should be watched, since any considerable loss renders the jacket inadequate. If the centrum was severely crushed, it is well to continue the use of the jacket for

convex portion of the curve of the vertebral column, the weight will be carried on the posterior wall of the centrum, and the patient should be ambulatory. If,



Fig. 351. *a*.—Fracture of the vertebral body with injury of the intervertebral disk. *b*, Position after reduction by hyperextension.

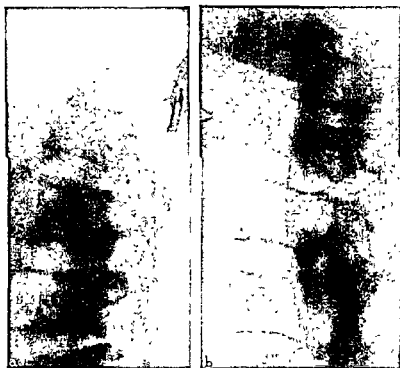


Fig. 352—*a*, Central compression type of vertebral fracture. *b*, Position after attempted reduction. Little or no decompression can be obtained.

another month or more. The patient with a jacket may be ambulatory provided the weight above the fracture falls on the intact posterior portion of the centrum. In other words, if the fracture lies in the anteriorly

however, this requirement is not satisfied, if there is lateral crushing or if the patient is obese, the same treatment should be carried on but with the patient recumbent. A plaster of paris shell may occasionally

be necessary. After the period of jacket fixation, a belt may be worn for about a month during which time exercises should be vigorously pushed.

**Exercises**—Active spinal extension and abdominal retraction should be started a few days after the reduction and kept up throughout the time of treatment. As fixation is being gradually withdrawn, lumbar flexion and pelvic rotation must be insisted on so as to obliterate the deep lordosis resulting from the hyperextension necessary to correction and fixation, otherwise, backache will ensue. By means of these exercises the ideal of treatment is achieved, whereby a normal range of motion and muscle strength are gained by the time the bone union is complete. In this way the patient is spared long periods of rehabilitation and discommodation.

**2. Fracture of Upper Dorsal Vertebrae (above the Eleventh) (Without Cord Injury).**—The difficulties involved in the reduction and fixation of the fractures in this region are so considerable and the results without reduction are so satisfactory that correction of the deformity is commonly not indicated. Instead, eight weeks of recumbency on a firm bed and intermittent head traction through the halter and extension exercises, to keep the cervicodorsal junction limber, are commonly employed for about six months.

**3. Cervical Body Crush Fracture (Without Cord or Root Injury).**—No dislocation is present, and the posterior wall of the body is not involved.

Reduction is obtained by hyperextension. The surgeon, holding in his hands the patient's occiput, gently lowers the head over the end of the operating table until reduction is complete, as verified roentgenographically. Anterior and posterior shells are then made, being carefully molded to the head, neck, torso and thighs. Spinal fusion is justified to eliminate sequelae.

**4. Fracture of Odontoid Process.**—Because of the peril of dislocation of the atlas on the axis, with consequent crushing of the spinal cord, adequate fixation is imperative. Gentle skeletal traction (5 to 15 pounds) applied through tongs<sup>8</sup> or wires<sup>10</sup> will prevent disaster. Internal fixation and fusion of the atlas and the axis is justifiable; otherwise a plaster jacket which includes the head and neck should be worn for at least four months, followed by a Doll or Thomas collar for several months more, until union of bone is demonstrated roentgenographically.

**5. Cervical Fracture-Dislocation.**—

Skeletal traction (10 to 30 pounds), applied through tongs<sup>8</sup> or wires<sup>10</sup> must be instituted as soon as the diagnosis is made. By it, further risk of cord or root injury is avoided; if nerve trauma is already present, further injury is avoided. Reduction is occasionally effected by this means alone. If by the traction, reduction is not complete, open reduction may be done under traction. This should be done only by those who are thoroughly competent. The procedure is difficult and demands special skill and an intimate knowledge of the pathologic changes. Inter-

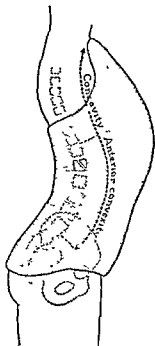


Fig. 333.—Diagram showing the extent of the plaster jacket used in the treatment of lower dorsal and lumbar vertebral fractures.

nal fixation and fusion is justifiable. Without fusion, recurrence of the dislocation (sometimes fatal) is not uncommon.

If, unfortunately, skeletal traction is not available, the Walton-Taylor manipulative reduction is indicated.

**Walton-Taylor Reduction.**—The patient, deeply anesthetized, lies on the operating table as for reduction of a simple fracture. A traction head halter is applied and is fixed by a band around the waist and back of the operator, who stands at the patient's head and exerts traction throughout the maneuver by leaning gently backward against this band. (1) The rotational deformity is gently increased in a right unilateral dislocation forward, the turn of the head is to the left. (2) The head is tipped gently away from the dislocated side. (3) The neck is gently hyperex-

tended and the head is turned to the front. A click audible to or felt by the operator often announces reduction. The ability of the patient to turn his head freely back to the same position demonstrates reduction. When the dislocation is bilateral the reverse maneuver is carried out for the other side. Fixation and after treatment are the same as those for simple fracture.

### 6 Fracture of the Transverse Process

—This type of fracture is frequently regarded as a grave injury but this is erroneous as such a fracture is in reality a minor injury. A firm adhesive plaster strapping, removed and renewed at five day intervals for several weeks is indicated. Rest in bed

done with the greatest care may result in damage to the cord or the nerve roots.

Reduction may be attempted by the suspension method (previously described) provided in the anteroposterior roentgenogram taken immediately before no disalignment of the posterior articular processes is seen (Figs 354 and 355). If the procedure is carried out slowly and without a general anesthetic the surgeon should be able to detect impending injury to the cord or nerve roots in time to avert irreparable damage. At the first sign of pressure on the cord or nerve roots the extension must be stopped and the

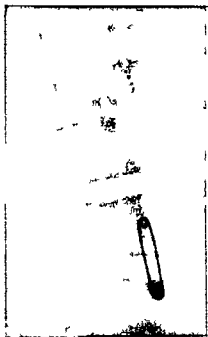


Fig 354

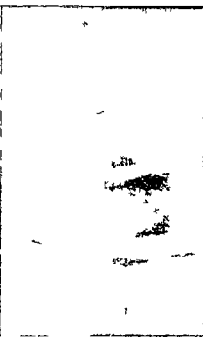


Fig 355

Fig 354—Fracture-dislocation of the spine. Hyperextension without distraction is dangerous to the cord.\*

Fig 355—Position after reduction of fracture-dislocation of the spine.\*

for one or two weeks is sometimes necessary when several processes are broken. Rarely extensive hematoma makes a plaster jacket or shell necessary. Attempts at reposition of fragments are not successful and are unnecessary. When healing is well advanced usually in two or three weeks exercises should be started. The period of disability usually lasts for one to twelve weeks.

### DISLOCATION (DORSAL AND LUMBAR)<sup>11</sup>

Reduction of a vertebral dislocation may be difficult to accomplish and when it is not

spine gently returned to the position present before extension was begun. A jacket is applied to safeguard the back until open reduction can be performed.

If, however, anteroposterior roentgenograms taken immediately before reveal lateral disalignment of the spinous and articular processes, manipulative reduction should never be attempted since cord or cruda damage may result.<sup>11</sup> Immediate open reduction is indicated.

Failure by extension to reduce a dislocation in such cases is due to locking of the posterior articulations. These processes can

\* Rogers Arch Surg 30

be freed by open reduction, a procedure which may prove very difficult. It should not be attempted by those not fully equipped and trained in neurosurgical technique. For this operation a local anesthetic should be used. As soon as the facets are freed (by flexion obtained by lowering the ends of the operating table) and realigned (by levering the posterior processes with a skid aided by the appropriate derotation of the trunk by a skilled assistant), the spine should be hyperextended and the jacket applied.

The after-care following reduction is the same as that for fracture.

**Prognosis and End-Result.**<sup>2</sup>—The treatment of these fractures has within the last ten years been raised to a level of efficiency on a par with that of most other fractures. When the condition is diagnosed early, when anatomic restitution is secured and when early active motion and adequate fixation are provided a return to full pre-injury activities in six to eight months is obtained in 65 per cent of the cases. This means that the normal healthy person who is properly treated may be expected to be as well six months from the time of injury as he was before the accident.

**Late Changes in the Fractured Vertebral Body and Intervertebral Disk.**<sup>2</sup>—The disorganization of the disk as a result of injury is followed by the development of replacement fibrosis. Since scar tissue is incapable of withstanding sustained pressure, much of the intervertebral space is lost, the loss being definite in 85 per cent of the cases. The normal local mechanics change with this alteration in structure, and there results loss of adaptability to changing stress and strain. Bone proliferations appear along the margins of the centrum, and the articular end-plates become denser. Some of the proliferations rapidly develop and in over 40 per cent of the cases form a complete bridge of bone across the intervertebral space, thus uniting the fractured with the adjacent vertebra. The vertebral column is so adaptable that these local changes have little or no effect on function as a whole and are usually not appreciable clinically, provided correction of the deformity of the vertebral body has been maintained.

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## FRACTURES OF THE PELVIS

Fractures of the pelvis are best classified as follows:

- 1 Those that involve the ring: (a) At one point of the circumference, (b) at two or more points of the circumference without displacement and (c) at two or more points with displacement upward of one side.
- 2 Fractures that involve bones entering into the formation of the ring, but the ring remains firm and unbroken, i. e., the iliac crest or wing the spine of the ilium, the tuberosity of the ischium and the sacrum below the sacrotuberous articulation.
- 3 Acetabular fractures: (a) involving the rim (b) involving the three segments and (c) perforating.

**Etiology.**—Some great force is always necessary for the production of a fracture of the pelvic ring, because this structure is strong and elastic. Prior to the age of rapid transit, falls from a height and crushing between logs or heavy bales of goods were the common causes of this injury. At the present time crushing between railroad cars, trucks or automobiles is the major cause, although there are many cases on record of persons who have sustained pelvic fractures while riding in a closed car when there has been a collision and the occupants have been thrown violently together, either by the force of the collision or by the overturning of the vehicle. The injured person in this type of accident seldom remembers the exact nature of the force that caused his injury. However, Maligne records a case of a fall from a height on an extended limb which caused

a fracture-dislocation upward of the same side of the pelvis.

In cases of isolated fracture of the anterior superior spine, the crest or the wing of the ilium, and avulsions of the ischial tuberosity, an exact history may be obtained. Blows or kicks on the perineum and a fall

lesion, and one entire side of the pelvis may be dislocated upward for from  $\frac{1}{2}$  to  $3\frac{1}{2}$  inches. This is called a *Malgaigne fracture* and is always very serious. The force necessary to cause it is so great that as a rule there is a high mortality rate, due both to the fracture and to the associated injuries. The fracture line through the posterolateral portions of the pelvis may be associated with a separation of the symphysis pubis, instead of a fracture through the bones forming the obturator foramen, and may be associated with a more or less true sacroiliac dislocation. But these conditions are not very common. It is extremely rare to see a fracture alone or in any combination that extends up through the middle of the sacrum.

Fractures of the iliac crests are very common. Avulsions of the anterior superior spine of the ilium or of the epiphysis of the ischial tuberosity are uncommon.



Fig 336—Fracture of the pelvis during pregnancy, which was not disturbed

across a fence or rail or on the tongue of a wagon are frequent causes of fractures of the inferior ramus of both pubis and ischium. On the whole the average person with a fractured pelvic ring has other serious injuries and a patient with multiple injuries must always be examined for a fractured pelvis and the visceral complications that so commonly accompany this lesion.

**Pathology.**—The pelvic girdle is most frequently broken through the bones forming the obturator foramen and of these the ramus of the pubis and the inferior ramus of the ischium are by far the most commonly involved. The superior ramus of the ischium is rarely injured in this type of pelvic fracture, but it is not uncommon to find bilateral fractures through each obturator foramen. These fractures through the obturator foramen may be the only fractures present, but there may be a fracture through the posterior portion of the ilium or the sacroiliac joint or sacrum which accompanies this



Fig 337—Fracture of the pelvis with involvement of the acetabulum and dislocation of the femur

Fractures of the acetabulum are steadily increasing in frequency, both because more are recognized and because more occur. They may be classified as follows:

#### A Fractures of the rim:

1. An oblong fragment on the posterior Ep of the acetabulum essentially that portion contributed by the ischium in its development.



- 2 An oblong fragment essent ally that portion contributed by the ilium
  - 3 An oblong fragment, essent ally that portion contributed by the pubic bone
- B** Fractures of the acetabulum involving one or two of the three bones which form it
- 1 Fracture with displacement inward and backward of the ischial segment and ramus
  - 2 Fracture with displacement inward of the pubic segment and ramus
  - 3 Fracture with displacement of both the pubic and ischial segments with ramus
  - 4 Fracture with displacement inward and backward of the ilial segment
- C** *Perforating fractures*  
In this type the lead is forced through the bottom of the acetabulum with a very small amount of the surrounding bone
- D** A fracture so extensive that all of the bones are involved and fragmented

The urethra and the bladder which lie in such close proximity to the pubic bones are frequently injured these complications often occurring with fractures that have not required much force. The rectum is not often injured but when it is the infection from it is so violent that it is usually fatal. The small intestine and sigmoid are less commonly involved. Injuries of the greater blood vessels are not unusual and when present are frequently fatal. There is a marked extravasation of blood in every pelvic injury, and this blood is almost always extraperitoneal sometimes extending over the lower part of the anterior abdominal wall. Often there is free blood in the peritoneal cavity resulting from an injury to the overlying peritoneum but without any injury to the viscera.

**Symptoms**—Any person whether conscious or unconscious who has sustained a fracture of the pelvis must be examined for other injuries. If this procedure is carried out in the admitting ward many lives will be saved. The best possible history of the accident and of the force involved should be obtained. Points of tenderness over the pubis, ischium, ilium and sacrum must be looked for carefully because sometimes the patient is too benumbed to be cognizant of pain but will react promptly to pressure on a point of tenderness. If the patient complains of any definite pain such a history should not be belittled because it is a most valuable symptom and will be of great aid in reaching a diagnosis.

Fortunately for the patient but unfortunately for the surgeon who is endeavoring to make a diagnosis the average person with a pelvic fracture will complain only on moving, being moved or having pressure applied over the area of bone injury. Careful palpation and inspection of the perineum are imperative in these cases and a rectal examination should be made with the finger carefully exploring around the inferior ramus of the pubis and ischium and well up on the superior ischial ramus. The convexity of the sacrum can also be outlined with the finger in the rectum but great care should be taken not to injure the rectal wall on any sharp spicule of bone because any perforation would free the violent pathogenic bacteria which are found in this segment of the intestinal tract. Gas forming bacilli are commonly present in the lower intestine and if they are freed into a large retroperitoneal hematoma they may cause a fatal infection. The superior ramus of the pubis cannot be accurately palpated but a marked point of tenderness with swelling and discoloration is very significant of bone injury. Rather large hematomas are common in injuries of the iliac crests and there are times when the evacuation of these great masses of blood by an incision will be of value. No drainage should be used. Deformities of the pelvis caused by crushing and displacement are common but they must be carefully sought for as they are not easily observed. Even when one pubic bone is dislocated up and over the one on the opposite side in a person of moderate size it does not cause an easily detectable deformity. A deformity caused by a  $\frac{1}{4}$  to 2 inch displacement of one side of the pelvis in a case of Malignant fracture has no great degree of visibility and must be carefully sought for by having the limbs parallel and the feet together. The surgeon must not take too much for granted after making a hasty inspection. Loss of function is variable in minor fractures but is always present in a severe fracture and the patient is helpless so far as pedal locomotion is concerned. The writer has never been able to prove to his own satisfaction the presence of a simple subluxation of the sacroiliac joint.

**Genitourinary Symptoms**—A small amount of blood in the urine is commonly

found in these injuries and may arise in the kidney bladder or urethra it is always an ominous symptom. Its origin must be determined as rapidly as possible considering the degree of shock in which the patient

and the bladder contains only a little bloody urine it is highly probable that the bladder has been ruptured and an exploratory operation is indicated at the earliest moment. A diffuse tenderness and semi rigidity of the

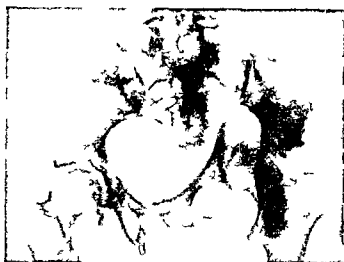


Fig 308—Severe fracture of the pelvis with central dislocation of the femur through the fractured acetabulum

may be it must also be borne in mind that a severely shocked patient does not pass much urine. The continuity of the urethra should be noted and the amount and character of the urine obtainable from the bladder should be ascertained at the earliest possible oppor-

timunity. The abdominal wall may arise from an extravasation of blood in the peritoneal space but marked tenderness and rigidity of the abdominal wall with scanty, bloody urine almost always indicate that there is either intraperitoneal or extraperitoneal rupture of



Fig 309—Same case as shown in previous figure after reduction

tunity. The test should be repeated at short intervals if there is any doubt as to the extent of the injury. If the bladder has been ruptured it is usually almost empty and blood is certain to be present. If the abdominal wall is rigid, semi rigid or very tender

the bladder. Occasionally 3 or 4 ounces of urine can be obtained from a ruptured bladder but it is not common as the pressure of the abdominal cavity on the fundus of the bladder prevents the expansion of the bladder wall and the urine is thrown out freely

into the peritoneal cavity or less freely into the peritoneal space. If the rupture is extraperitoneal the lower portion of the abdominal wall will be swollen and boggy, not infrequently the scrotum in the male and the labia in the female are swollen and edematous. These findings may be corroborated by the injection of a sterile solution into the bladder and noting the amount that is recovered. If the entire amount of injected fluid is not recovered it is proof that there is an injury to the bladder wall. This test is of value when shock is so marked that little if any urine is being secreted. Another procedure is the injection of air into the bladder and the use of the fluoroscope or the x-ray plate to determine whether the bladder is distended or whether the air passes into the abdominal cavity. The objection to the injection of sterile solutions is that it may cause the spread of any infection that may be present. The objection to the injection of air is that in a certain number of cases death will result from air emboli.

**Symptoms in Acetabular Fractures.**—Fractures of the acetabulum of a minor type such as of the rim without the involvement of a displaced segment are extremely difficult to diagnose from the physical findings. Fractures either of the pubic segment or of the ischial segment without marked inward displacement are also extremely difficult to detect by physical examination. The following signs are of great value: a marked inward displacement or a central dislocation, the flattening of the trochanteric region, the limb on that side being of normal or increased length, the limitation of abduction and the extreme pain on abduction or any other movement of the thigh. If rectal examination reveals tenderness high upon the side of the injury with more or less boggy-ness due to extravasated blood and joint fluid, one can be almost certain of the condition present. The final diagnosis, however, must depend on a very careful roentgenologic examination with several plates taken from various angles.

**Diagnosis.**—The actual diagnosis of a fracture of the pelvis is not difficult if the surgeon makes a careful physical examination and checks this with roentgenograms. Complications such as the rupture of a vessel or one of the great vessels will be the

cause of grave concern to determine the correct line of treatment.

**Prognosis.**—A search through the literature on fractured pelvis discloses a marked variation in the mortality statistics. In those cases in which a definite diagnosis of fracture of the pelvis was made either clinically or by postmortem examination there was a mortality of from 10 to 17 per cent. Many cases of fractured pelvis are overlooked under the vague clinical diagnosis of internal injuries, such as ruptured kidney, ruptured spleen, ruptured vessel, etc., but an autopsy in these cases frequently reveals that the true cause of death was a fractured pelvis. The prognosis as to disability varies. As a rule the charity patient with a fractured pelvic ring is in good condition at the end of four months or even less, but in an industrial case with medicolegal complications there is an average of from six to eight months of temporary total disability with varying degrees of partial permanent disability (usually not truly permanent).

**Treatment.**—The average fracture of the pelvic ring involving the rami of the pubis and ischium with little or no displacement will heal perfectly and function is restored in twelve weeks. The patient spends from five to seven weeks in bed without any particular dressing and then is allowed to be up and around for from three to five weeks after which he may resume any ordinary occupation. If his occupation requires heavy labor at least sixteen weeks must elapse before he may return to work. If there is a wide separation of the fragments (about one in seven cases) the patient may be suspended in a sling. If this separation is in a muscular man a broad heavy band of molskin adhesive plaster placed below the crests of the ilium and over the trochanters of the femur may give adequate support and great comfort. But in a fleshy man or woman an adhesive band is as a rule unsatisfactory because its edges roll up and irritate the skin. The patient may be suspended in a hammock attached to a Balkan frame. The supports of this hammock may be hung vertically or if necessary can be crossed above so as to increase the lateral pressure on the displaced fragments. Too much lateral pressure with multiple pulleys and with the ropes crossed from side to side can easily crush a

pelvis and is a source of danger. This type of treatment must be used with the greatest possible care.

If there is a displacement over one side of the pelvis—a *Malgaigne fracture*—every possible effort must be made to reduce the displaced fragments into position. This may be accomplished by traction on the injured limb of 50 to 75 pounds of weight with a counter pull through a belt beneath the opposite tuber ischi. If this is not successful the patient should be placed on a Hawley table and extension made with the screw traction with the firm side of the pelvis fixed against the center post and extension made on the opposite extremity. The writer has succeeded in reducing one fracture of this type that was of ten days' duration by fixing the limbs in the Hawley table and then manipulating the torso abducting it from the injured side. An avulsion of the anterior superior spine of the ilium of an ischial tuberosity is sometimes so painful that replacement and fixation are required. A fracture of the crest of the ilium seldom requires any type of treatment other than the aseptic evacuation of a large hematoma. A fracture of the sacrum is best treated with rest and quiet, the prone position being the most comfortable. Dislocation of one pubic bone over the other is rare but should be reduced by manipulations or open operation as the pain and discomfort without reduction are sometimes very severe. A true dislocation of the sacrospinous joint has been very uncommon in the writer's experience. A fracture of the acetabulum should be accurately diagnosed and carefully treated as it will be the cause of very serious disability if not corrected. To abduct and extend the limb of the injured side will be sufficient to reduce the usual displacement if treatment is begun early. In some cases a band around the thigh with lateral traction in addition to the longitudinal traction is sufficient. In other cases it is necessary to drive a large screw into the neck of the femur and thus make adequate lateral traction. In other cases the head of the femur is driven through the acetabulum and the fragments lock the head into position so that an open operation is required to release the femoral head. It can then be held in position with longitudinal traction. From ten to fourteen weeks of recumbency are

generally required. Each of these methods and means may be necessary in some certain complicated conditions and there are times when the damage has been so severe that any manipulation or extension whatsoever is precluded. When there is doubt about the presence of a rupture of an abdominal viscus an exploratory operation should be performed.

WILLIAM R. CUBBINS

## FRACTURES OF THE FEMUR

**General Considerations.**—Fractures of the femur constitute an important group with a high percentage of disability. The disability percentage is too high in the light of present-day knowledge and experience and the attempt will be made in this article to present as clearly as possible the modern concept of the handling of the various groups into which femur fractures can be conveniently divided and the factors involved in the choice of methods for the individual case. Details of treatment methods must necessarily merely be indicated when the method is particularly involved. No attempt is made to present statistical studies. Their value is largely academic and their application to the individual case is hard problematic.

The essential idea underlying the treatment of all fractures is the function of the part. In the lower extremity it is primarily that of weight bearing and shifting of weight bearing known as locomotion. This makes the aim of treatment quite different from what it is in the upper extremity in which flexibility and range of motion are the essential aims. Although an inch of shortening or a 10 degree angular deformity in the humerus is of no functional significance, it becomes of vital importance in the lower extremity. The best evaluation of the importance of this concept lies perhaps in a comparison between our attitude toward fractures of the surgical neck of the humerus where the head is angulated somewhat but impacted and a similar condition in the neck of the femur. The two bones are analogous with heads offset on the shafts by an intervening neck. The femoral neck is merely somewhat longer than the humeral one. In the first case the deformity is not disturbed early even immediate active function is per-

tuted and rapid return of a normal range of motion and flexibility is sought. In the second instance considerable risk is taken to secure adequate anatomical restoration even breaking up impacted angulation and prolonged immobilization are practiced to maintain corrected position with risk to life and the range of joint motion. The difference in practice is due to the difference in the aims of treatment based primarily on the function of the part. Of course it is desirable to maintain all the motion possible in the lower extremity—in fact this has been the driving force in developing modern methods of treatment, but the functional anatomy is of prime importance.

With this concept of therapeutic aims fractures of the upper extremity of the femur will be considered as one group, fractures of the shaft as a second group and fractures of the lower end as a third group.

#### FRACTURES OF THE UPPER EXTREMITY OF THE FEMUR

There is considerable comfort in the fact that a *laissez faire* attitude, visions of band-aids and a hopeless prognosis are no longer considered part of the picture presented by fractures of the femoral neck. Today the case which justifies such a viewpoint and course of procedure is a rarity. True there is still much room for improvement but as a result of the investigations of the problem in the last twenty years not only has a great deal been accomplished but further advances leading to still lower mortality and better results may be confidently looked for in the next decade.

Past, present and future victims of this deplorable fracture owe an immeasurable debt to Royal Whitman for his militant missionary work in this field. No one person has been so important a factor in forcing intelligent and progressive study or has contributed so much to aid in that study. In addition to the contributions and influence of Dr. Whitman we have today in our attack on the problem the aid of increasing knowledge of the anatomical characteristics of the part, of the value and significance of adequate roentgen studies both before and after reduction, of the wide variations in the initial pathology and of the course and character of the healing process.

It may seem that an inordinate amount of space is devoted here to anatomy and pathology but a knowledge of the essential anatomy of the femoral head and neck and their soft parts and of the pathology of the various fractures is of paramount importance in the formation of any intelligent plan of treatment.

In figure 360 I it will be noted that there are five sources of blood supply to this general bony region: the ligamentum teres, the vessels accompanying the capsular attachment to the neck, those accompanying the reflection on to the neck of a thin layer of capsule together with synovia up to the articular edge, the nutrient vessels at the base of the neck and a multitude of small vessels derived from the muscular attachments about and along the intertrochanteric region entering via the periosteum. These latter constitute in point of total volume a large part of the circulatory supply to the intact bone. The intact neck of the femur is then far from deficient in circulation. The complicating factor lies in the fact that all or the major part of the circulation to a fracture site must often be derived from soft part sources outside the bone and not from its intrinsic or nutrient vessels once fracture has occurred. Comparison of figure 360 I and II demonstrates what occurs as regards circulation in the various regions of the femoral neck following fracture.

Assuming each fracture line to be complete with tearing of all vessels across the line of fracture it is readily seen that when the fracture occurs across line 1, the so-called subcapital fracture, the proximal fragment has for its blood supply only those vessels, small and few in number, which enter through the ligamentum teres. In some instances this ligament contains no vessels which actually reach the head of the bone. At all events the head is cut off from B, C, D and E as sources of circulation. If the fracture occurs between lines 1 and 2, the proximal fragment has as an additional blood supply only such circulation as has remained intact by reason of untraumatized portions of capsular reflection. While it is true that the circulatory supply B of the capsular attachment itself is profuse, the reflection of the capsule on to the intracapsular portion of the neck is extremely thin in

places practically lacking so that circulation C at the best is scanty and if there is separation of the fragments to any degree this circulation becomes nil as regards the proximal fragment. The head is then no better off than following subcapital fracture. When the fracture occurs between lines 2 and 3—the so called base of the neck—the proximal fragment retains circulations A and C plus those vessels from sources B and D which lie proximal to the fracture line. When the fracture lies between lines 3 and 4 the proximal fragment retains circulations A B C D and all of the rich circulatory supply E will be discussed.

supply unless extensive retrograde thrombosis occurs following fracture. It is also obvious that in any given fracture all the vessels crossing the fracture line may not be ruptured or thrombosed and that in subcapital and intracapsular fractures the capsular reflection may not be completely torn.

Apart from the problem of the actual life of the proximal fragment, studies of bone repair have pointed out the varied significance of adequate circulation in that process.

*It is therefore advisable to remember from the standpoint of prognosis that it is impossible to state at the outset for the specific case of intracapsular fracture how much cir-*

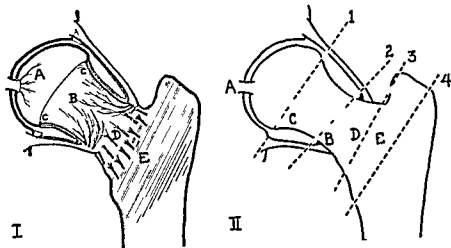


Fig 360—I Sources of blood supply for the femoral neck. A From the ligamentum teres scant and sometimes missing. B from the capsular attachments numerous large vessels. C from the capsular reflection and avulsion small short vessel. D nutrient vessels numerous and good sized. E from the extensor muscle attachments in intertrochanteric region (shaded area). In the intact femur these vessels anastomose freely. II (compare with I) Effect of fracture on blood supply to the proximal fragment. Assuming the fracture to be complete in each instance the proximal fragment retains after: Fracture 1—blood supply 1 only. Fracture 2—blood supply A plus C. Fracture 3—blood supply A plus B plus C plus D. Fracture 4—blood supply practically intact.

These two latter fractures lying between lines 2 and 3 and 3 and 4 are a separate group clinically except for the physical signs and symptoms. The prognosis and treatment are entirely different from those of the first two groups. The latter will be considered first under the designation of intracapsular fracture and later the differences presented by the two other groups under the terms base of neck and intertrochanteric fractures will be discussed.

### INTRACAPSULAR FRACTURE

#### (Subcapital and Through the Neck)

It is of course obvious that in all instances the distal fragment has an adequate blood

supply. The prognosis must necessarily wait until the extent of circulatory damage becomes apparent in bone changes noted in the roentgenograms. This is a question of weeks not days.

In addition to the pathology involving circulation in these fractures one must also keep in mind the fact that there is no characteristic displacement of the fragments. There may be no displacement at all, merely a crack showing across the bone. When the fracturing violence is directed against the greater trochanter which is unusual the displacement is apt to be that of a varying degree of impaction with a tendency to coxvalgia (Fig 361 3).

Tearing of the soft parts and primary circulatory damage theoretically should be at a minimum in these two groups of cases although secondary thrombosis of vessels may eliminate this favorable factor. Ordinarily the displacement, when it is present is the result of a variable amount of downward force of the pelvis exerted on the head plus a torsional force due to twisting of the body. This results in various degrees of *coxa vara*

It is apparent that the damage to the various circulations is more complete with the increasing degrees of displacement, since this predicates more and more tearing of the capsular reflection and of the attached soft parts.

In the higher fractures the intracapsular and the subcapital actual death of the proximal fragment may occur a condition which Phemister has called aseptic necrosis

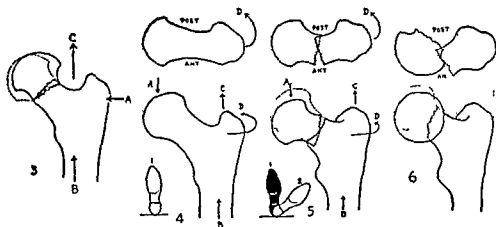


Fig 361—3 Fracture following violence against the trochanter. Dotted line represents normal position of the head. Shaded area represents impaction. It will be noted that the pull of muscles running from the upper femur to the pelvis and trunk tends to impact the position further (force B) and that weight bearing has the same tendency (force C). Compare with the effect of these forces in the normal neck (4) and in the presence of fracture with *coxa vara* deformity (5).

4 Forces involved in production of the usual deformity in fracture of the femoral neck. A Downward force of the body via pelvis after stumble. B Resistance of fixed leg and foot. C Upward pull of muscles running between thigh and trunk. B and C both tend to augment action of A (compare with 3). D Torsional force tending to produce horizontal angulation. The inset shows normal position of the foot in the supine patient. Compare with 5.

5 The effect of the torsional and impact forces shown in 3. Note that the force D is responsible for the outward rotation of the thigh, foot and leg as represented by the characteristic position of the foot 2 as compared with the normal position 1. Note that the shortening is caused by the forces A, B and C. The dotted outline represents the normal position of the head. The impaction is principally inferior and posterior. Note that the muscular forces C tend to increase *coxa vara*. Compare with similar tendency in the normal (4) and the effect of these forces in presence of *coxa valga* (6).

6 Position which may be reached by fragments in extreme angulation due to torsional forces. This is not uncommon. Note the circular appearance of head when viewed from in front referred to in figure 362 A2-E2 and 43-F3 and of much importance in the planning of reduction. The head may look posteriorly with its articular face instead of anteriorly as here shown.

and of angulation in the horizontal plane with the angle opening backward (Fig 361, 4 and 5).

If the torsional force is extreme the fragments assume the position shown in figure 361 G, not only with no impaction but with out contact of the fractured surfaces.

It is well to realize that this is not of infrequent occurrence and that the reduction maneuvers will fail to secure apposition of fractured surfaces unless modified to meet this situation.

This is an extremely unfortunate complication particularly if not recognized and modifies tremendously both the prognosis and the treatment. Unfortunately it can be revealed only by roentgenographic changes some weeks after injury, but the possibility must always be kept in mind.

Many so called intracapsular fractures of the neck are fortunately sufficiently oblique so that at least part of the fracture line particularly below and behind lies below the point of capsular reflection in the region

designated D in figure 360 II thus insuring some degree of circulation to the proximal fragment. Recognition of this fact is a matter of import in prognosis and in treatment.

For the general features of the healing process the reader is referred to the section on repair of fractures. It is desired to call attention here merely to the extraordinary features in the process which manifest themselves in this region characterized by universally slow union and all too frequent non union. The paucity of circulation for nutritive and biochemical transformation purposes and of vascular soft parts available for the growth of granulation tissue to form the basis of callus even when reduction and fixation are adequately carried out is the factor responsible. The present day attack on the problem is centered on these anatomical and pathologic features and what is most needed for improvement in general results is adequate carrying out of efficient closed or conservative methods in general hands. To the closed methods there has been added as a relatively conservative procedure that of closed reduction followed by internal fixation applied through an incision which exposes only the lateral trochanteric region. This will be described in the section on operative treatment. Open reduction at present should be definitely limited to selected cases in selected hands and under restricted conditions with the realization that open reduction of the femoral neck is at present not generally justified. This point will be further elaborated under the discussion of operative treatment.

**Roentgenography**—One of the difficulties in securing results in intracapsular fractures of the femoral neck by closed methods has been engendered by inadequate roentgenography. As has been pointed out in the description of the pathology of this lesion the position of the fragments determines the details of the reduction procedure and with certain rather frequent displacements the routine procedures cannot possibly result in reduction unless modified to meet the condition revealed by the roentgenograms. It is often extremely difficult to define the position of the fragments in a flat plate accurately enough to be of any practical value. The points of paramount im-

portance in the analysis of position as shown in flat plates are illustrated in figure 362 A<sup>1</sup>—E<sup>1</sup> A° E. The use of stereoscopic plates naturally makes the determination of position an easier matter but they may be misleading unless accurate note of the points mentioned in the discussion of flat plates is made.

The introduction of methods allowing the taking of more or less lateral views of the femoral neck has made it possible by combining anteroposterior stereoscopic plates and a lateral view to obtain a more accurate idea of the relationship of fragments and therefore to use reduction procedures intelligently and more successfully. The value of lateral plates is briefly shown in figure 362 A<sup>3</sup> E<sup>3</sup>. These lateral views can be secured without untoward difficulty. Two simple methods are those developed by George and Leonard and by Manfredi and Darrach. The former involves employment of a special curved cassette and is illustrated in figure 363 1. The latter makes use of an ordinary cassette and is illustrated in figure 363 2. Discussion of the roentgenographic check following reduction is best combined with discussion of the reduction itself since it is an indispensable part of that procedure. The roentgenographic checks revealing the progress of the healing process, changes of position with or without evidence of absorptive changes and the occurrence of aseptic necrosis are all vitally concerned in treatment and will be presented under that heading.

Too much emphasis cannot be placed on the adequate roentgenography of fracture of the femoral neck with careful study and adequate interpretation thereof both before and after reduction.

There can be no question but that many of the cases of non union which help to make the care of intracapsular fractures the problem which it is result from inadequate knowledge of the position before attempted reduction, resultant failure to secure adequate reduction and failure to recognize inadequate reduction in subsequent roentgenograms. The problem of union in these fractures is complicated enough at the best without these added barriers to success.

**Etiology**—These fractures occur ordinarily in elderly persons and more frequently in women. The greater tendency to fracture



in these persons has been laid to decalcification of the bone secondary to changes due to age and decreasing bodily activity. Re-

stituents of the bone. This would make for a clearer understanding of the "brittleness." This, plus the fact that the neck of the

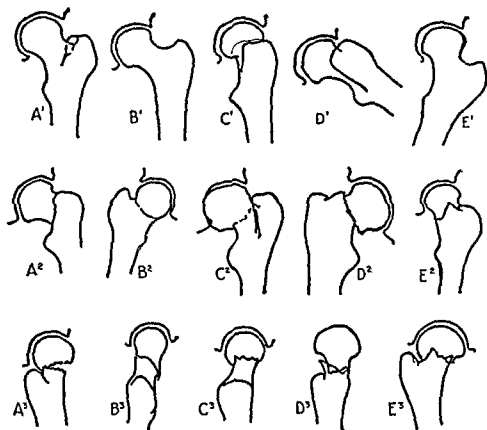


Fig 362—A¹, Normal hip in neutral position. Head outline is semicircular. Compare direction of first portion of lower margin of neck with D¹ (abduction) and E¹ (adduction). Moderately prominent lesser trochanter, slight shortening of neck and slight broadening of greater trochanter. Compare position of articular margin of head in acetabulum with D¹ and E¹. B¹, In internal rotation. Lesser trochanter has disappeared, neck shows full length and greater trochanter is seen in sharp profile. C¹, In outward rotation. Marked prominence of lesser trochanter, quadrilateral face-on view of greater trochanter, marked shortening of neck, head outline approaching the circular instead of the semicircular. D¹, Appearance as in C¹ but the addition of abduction has changed the direction of the first portion of lower margin of neck and caused the lower portion of the articular outline to project beyond the lower edge of acetabulum and the upper portion to withdraw into the acetabulum. E¹, Appearance as in A¹ but the addition of adduction has changed the direction of the first portion of the lower margin of the neck and caused the lower portion of the articular outline to recede within the acetabulum and the upper portion to project beyond acetabular edge. Observation of these various points in a flat plate will give some idea of the positions assumed by head fragment and neck fragment.

A², fracture through mid neck. Head fragment markedly abducted. Shaft in slight abduction and moderate external rotation. At operation the raw surface of the head lay in contact with dorsal surface of neck fragment. B², Abduction and midrotation of neck fragment. Head fragment flexed and rotated so that its raw surface looked directly forward and lay against back of neck fragment. (Compare Fig 361.) C², Abduction and marked flexion of head fragment. Outward rotation and forward displacement of neck fragment (proved at operation). D², Moderate abduction of head. Neck fragment rotated outward and displaced forward (proved at operation). E², Note adduction of head, moderate external rotation of neck. Stereo shows overlapping to be on different planes and not due to impaction.

Lateral views taken by Manfredi technic. B³ is the only one showing good apposition. All five looked satisfactory by ordinary flat plate standards. A³ shows forward angulation on with resultant gap. C³ shows forward angulation and rotation. D³ and E³ show anteroposterior angulation and rotation. (After Darrach and Stimson.)

cent investigations tend to show, however, that in addition to the decalcification there is also a marked decrease in the organic con-

femur is subjected to cross strain and to torsional strain intensified by the momentum of the body weight, readily explains

the frequency of the fracture in the aged in common with Colles fracture and the mildness of the trauma which frequently causes it

The fracturing violence is of two types and the recognition of the violence involved is of importance in treatment and prognosis

One type is that embodied in a misstep on the stairs or in stepping from a street curb or a slip on a rug or a polished floor. As a result there occurs a sudden precipitation of body weight on the affected limb with

the majority of cases the fall on the trochanter follows the fracture and is not an etiological factor

The brittle quality of these bones makes it possible for fracture to occur with a minimum of violence and any complaint of hip pain following even the mildest trauma in an elderly person places on the doctor the burden of proving that there is *not* a fracture of the femoral neck even though the patient can walk and has no demonstrable deformity

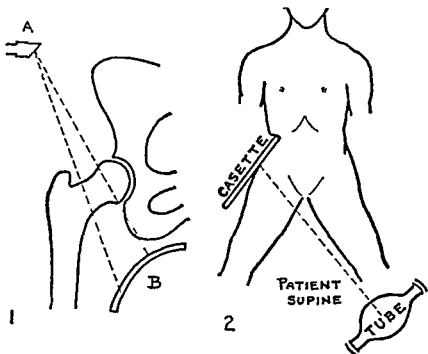


Fig 363—1 Lateral x-rays using curved cassette (George and Leonard) Patient supine Marked abduction not necessary A Target of tube, above iliac crests B curved cassette in perineum closely applied to curve of the neck This method has the disadvantages compared with the Manfred method, of requiring a special cassette and of producing probably more distortion

2 The Manfredi technique for lateral views The patient lies supine with legs abducted and cassette is pushed in over iliac crest and beneath costal margin The tube is close to the bed near the patient's opposite foot

cross strain on the femoral neck and practically invariably a twisting effort at recovery with a coincident torsional strain (Fig 361 4) The resultant deformities are illustrated in figure 361 5 and 6 The other type is that in which there is actually a blow against the greater trochanter without cross strain or torsion producing some impaction with a tendency to *cavus valgus* and a minimum of soft part *viz* circulatory damage (Fig 361 3)

The patient will almost invariably give a history of having undergone this second type of violence—a fall on the hip but in

Diagnosis—For purposes of discussion the fractures of the upper extremity of the femur are commonly divided as follows

- 1 Intracapsular—subcapital—through the neck
- 2 Extracapsular—base of the neck
- 3 Intertrochanteric—peritrochanteric

These groups often present indistinguishable pictures as far as symptoms and signs are concerned It is best perhaps to present first the classical picture of these fractures and then the variations which may be encountered

The patient has . . . and a . . .

misstep following a stumble or has been hit by a moving object, such as an automobile. Coincidentally there has been pain in the hip or groin and inability to use or to stand on the affected leg. When the patient is examined in the supine position, it is noted that the foot on the painful side is outwardly rotated, sometimes to such an extent that its lateral aspect lies flat on the table or bed (Fig 361, 5). Any movement of the leg causes pain in the hip or groin, more particularly abduction or internal rotation, the

have the thighs in the same degree of rotation and of abduction. The importance of these points should be obvious, as should also be the fact that it is necessary to put the sound leg in the position assumed by the injured one. The measurements are made from the anterior superior spine to either the internal or the external malleolar tip. Measurements may be exceedingly misleading unless made exactly.

Nélaton's line is a line passing from the anterior superior spine of the ilium to the

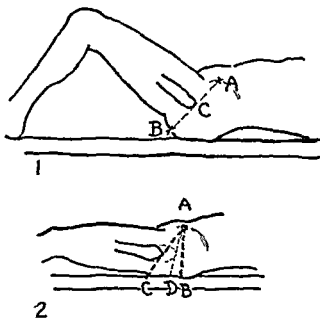


Fig 364—1, Nélaton's line. A, Anterior superior spine of ilium, B, tuberosity of ischium palpated in buttock, C, tip of greater trochanter. It can be readily seen that in coxa vara or in upward riding of the neck, the trochanter is elevated above this line.

2, Bryant's triangle. The heavy lines represent the normal. The light lines represent the condition in fracture with shortening. AB, Perpendicular from anterior superior spine to the table or bed, AC, line drawn from anterior superior spine through tip of normal greater trochanter to table, defining distance CB, normal base; AD, line drawn from anterior superior spine through tip of great trochanter elevated owing to coxa vara or upward riding of neck on head, defining DB, shortened base in this condition. The value of this determination lies in the fact that it translates a small difference in level of the great trochanters into a larger and more definitely determined base line difference.

latter being practically impossible. Inspection alone may show that the affected leg is shorter than the sound one. If this is not apparent to the eye, actual measurement plus comparison of Nélaton's line and Bryant's triangle on the two sides will reveal a varying degree of shortening.

In order to make measurement of any value it is essential to have the two anterior superior spines of the ilium on the same level, to have the hips and knees in the same degrees of flexion on the two sides and to

ischial tuberosity, with the hip in 40 degrees of flexion and in the mid-position without abduction or adduction. Such a line in such a position of the patient will pass through the tip of the greater trochanter on the sound side, but distal to it on the injured side if there has been shortening due to femoral neck fracture (Fig. 364, 1). Bryant's triangle is pictured in figure 364, 2, and presents a shortened base of the triangle as a result of shortening of the extremity due to injury of the femoral neck. In addition to

these signs the hip on the affected side is apt to be definitely more prominent than the hip on the sound side

With such a picture it should be impossible to miss the diagnosis. When however the visible outward rotation is slight and the shortening is not marked particularly when impaction sufficient to provide some degree of fixation is present the diagnosis will be frequently missed unless the measurement is carefully made of Nelaton's line and Bryant's triangle is accurately gauged. In these doubtful cases and in those presenting no gross deformity the presence of pain on attempted abduction or internal rotation eliciting of pain in the groin by a sharp blow of the closed fist on the heel of the extended leg or over the trochanter and direct tenderness in the groin are of significance. In the presence of any of these signs the case should be handled as a fracture of the femoral neck until adequate roentgen examination can settle the question. This viewpoint is important in that patients having impacted or non-displaced fractures may actually be able to walk about with only slight discomfort.

In the elderly unconscious patient following accident the hips should always be carefully examined for the possibility of fracture and if the gross signs are not present muscle spasm on movement and/or restriction of motion range particularly abduction and internal rotation should make adequate roentgen examination essential in order to rule out the possibility of fracture.

In testing rotation of the thigh it is important to grasp the knee and thigh and to gauge the movement by the position of the patella. Rotation of the foot is not an adequate gauge of hip motion because of the great amount of movement possible in the subtarsal joints.

**Treatment**—In the treatment of these cases the fact that the patient is often aged and suffering from ailments common to old age is frequently allowed to exercise too great an influence in the choice of method. Every patient of course requires a careful and complete physical evaluation but the finding of cardiac lesions of chronic bronchitis and emphysema of nephritis or of vascular lesions does not mean *ipso facto* that inefficient treatment or no treatment is in-

dicated. It means merely that these lesions must be treated in addition to not to the exclusion of the fracture. Those instances in which a fatal outcome can be assumed to be the result of adequate treatment of the fracture when combined with adequate treatment and nursing of the patient are few and far between. Most of such patients face under the same type of general care just as great risk of mortality with rest in bed and sand bags or with traction suspension as they do under properly nursed plaster immobilization. If the care and supervision of the patient cannot be adequately carried out the mortality will be high in either instance. If it can be adequately carried out the mortality will be lower in those cases in which the fracture is adequately cared for. The idea that reduction of the fracture and proper immobilization after reduction have been the fatal element in these cases has been a tremendous handicap to the general adoption of adequate methods.

It is also to be kept in mind that paradoxical as it may seem at first glance the worse the general condition of the patient, the more vital the necessity for internal fixation just as soon after injury as possible with active mobilization of the patient as a whole thereafter.

**Emergency Treatment**—The use of the Thomas type of splint with fixed traction as advocated by the Fracture Committee of the American College of Surgeons is a temporary immobilization pending definite treatment of extreme value in these cases. While it does not immobilize the hip joint, it keeps the fragments adequately fixed and prevents further deformity and damage by the maintenance of constant traction. It should be applied as soon as the diagnosis of fracture or suspected fracture is made and kept on during the transportation to the hospital and to a bed from the x-ray room and during preliminary treatment of the patient until definite treatment is undertaken.

If a Thomas type of splint is not available then a long Liston board splint from the axilla to beyond the foot should be applied but it is infinitely less effective. In an emergency the two legs and the hip can be bandaged together, the sound side acting somewhat as a splint for the injured one. Numerous numerous methods of applying traction without the use of the Thomas (Keller-Blake) type of splint have been devised. The reader is referred to the section on the emergency treatment and transportation of patients with fractures for the details.

If the patient is in shock this should be combated by the recognized methods. Since the trauma involved in the average case is relatively mild shock is not present. However with the Thomas splint

a procedure which takes less than five minutes and which should be devoid of pain, discomfort or added shock to the patient as much time as is needed may be safely taken for the treatment.

Since the patient is usually aged and subject to the general diseases of oldsters of the age group it is essential to evaluate his condition thoroughly before the treatment of the fracture is started in order that whatever disease he may be suffering from can be adequately cared for concurrently with the fracture. Emphysema and chronic bronchitis, arterial sclerosis (generalized cerebral or renal), hypertension, renal disease, cancer disease and diabetes are among the problems presenting themselves. It should be distinctly understood that probably none of these conditions has any effect on the healing of the fracture. Their effect is apparent principally in the mortality rate. Nor is any one of them more than a temporary bar to the adequate treatment of the fracture unless the patient is fractally moribund. But the accelerated termination of the presence or absence of vital importance in deciding what treatment the patient must have consistent with the treatment of his fracture. It is false to carry out this primary careful evaluation of the patient which is responsible for the grossly asumptive that a plaster cast is an important element in the mortality rate of this fracture. It is also to be remembered that it is wise to delay internal fixation if it is to be used for days in order to make the evaluation. Some hours of delay for the treatment of real shock is justified but three or four days rest is bad before operation is definitely more of a handicap than a help.

Following the application of the Thomas type of splint the treatment of whatever shock may be present, the taking of a leguiste roentgenographic a temporary or preferred stereoscopic and lateral views and the careful evaluation of the patient as a whole the patient and his fracture can then be treated intelligently.

**Reduction**—This may be accomplished by a closed or an open method. As previously stated open reduction should be reserved at present writing for selected cases in special hands. The method of choice for the average surgeon is the closed method preferably followed by internal fixation applied through an incision over the lateral trochanteric region.

Any one of a variety of anesthetics may be employed. Local anesthesia (injection of novocain into the hematoma about the fracture) may be excellent if the reduction can be done within a few hours after the injury. Gas oxygen with or without basic nitrogen (from 60 to 80 mg per kilo) is usually very satisfactory. Spinal anesthesia particularly with the use of pontocaine which prolongs the anesthesia for two or three hours may be very successfully used.

To avoid the large drop in blood pressure that frequently occurs with spinal anesthesia particularly in cases of hypertension unilateral anesthesia can be secured by employing a heavy specific gravity pontocaine and a special technique. In patients showing but slight displacement and requiring but little manipulation a large dose of morphine or rectal paraldehyde may be quite adequate.

**Closed reduction** is best accomplished by either of two methods. The first is that of Whitman slightly modified in view of more accurate present day knowledge as to the position of fragments gained as the result of stereoscopic and lateral roentgen studies (Fig 360 1-4). The modification consists in the application of outward traction to the thigh preceding and accompanying the downward traction with the object of disengaging the fragments preliminary to placing them in their proper relationships. In addition to accomplishing this the maneuver is practically essential when the deformity is that represented in figure 361 C in order to remove the pressure of the neck from the head fragment so that the latter may drop back or come forward as the case may be to the position where it is possible to get the broken surfaces in contact.

The second method is that of Leadbetter (Fig 365 5 and 6). The flexion of the hip in this instance secures relaxation of the muscles about the joint thereby having the same effect as the outward traction in the Whitman method since it relieves muscular tension and spasm which maintain pressure of the neck against the head fragment.

A matter of importance in the reduction is that one strives to attain not anatomical reposition but actual *covax* of mild degree. It is in effect a slight overcorrection of the deformity in order that the normal forces of the muscles running between the pelvis and the thigh and the impact of weight bearing shall both tend to force the fragments more tightly together in place of exerting a shearing strain at the fracture site with tendency to produce *covax* as is the case in the normal femoral neck (Fig 361). The importance of this overcorrection has been increasingly appreciated within the last few years and a satisfactory reduction is to be considered one in which slight *covax* valgus position has been attained rather than

one in which normal anatomy has resulted This elimination of a shearing strain is of progression of coxa vara deformity on weight bearing which is often seen after the

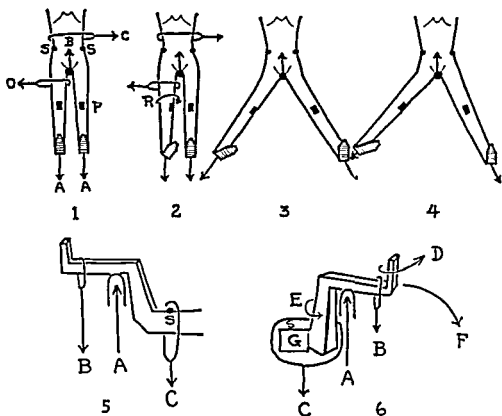


Fig 365—The Whitman reduction (modified) 1 A Traction downward on legs against counter traction B in perineum (post in table or rolled sheet passed through perineum and fastened to head of table) concurrent traction C (against crest of ilium—manual or by swathe around thigh and operator's waist) against counter traction O (against crest of ilium—manual or by sheet fastened to opposite side of table) O disengages the fragments and A should restore normal length SS the anterior superior spines must be kept on same level at all times P the patellae both look directly anteriorly and the feet point anteriorly

2 A B O and C continued Thigh just above the knee is rotated (R) inward strongly Patella now looks inward on treated side foot points inward correspondingly No strain on knee or ankle It is wrong and harmful to perform this rotation using the leg or the foot as a lever since the knee or ankle and knee are then under strain and are apt to be uncomfortable and to stiffen up immoderately in plaster

3 O and C released A and B maintained and both legs carried out to full physiological abduction as far as by limit of sound side Inversion of injured side maintained

4 Injured side carried a little beyond normal abduction limit to secure mild coxa vara, and impaction, and into mild hyperextension

5 and 6 Leadbetter method of reduction The patient lies supine on the table 5 The anterior superior spines (S) are held firmly down (manually by an assistant or by a swathe passed underneath the table C) The operator faces the patient's feet and with his shoulder underneath the calf at A as a fulcrum and upward push and his two hands over the front of the leg at B exerting a downward leverage secures powerful traction in the longitudinal axis of the femur The flexion relaxes the musculature about the hip joint and thereby relieves the tension which is holding the displaced fragments tightly together in addition by the exerting of lateral leverage during the procedure the fragments can be actually pulled apart (Compare force O in Whitman method modified)

6 Traction and lateral leverage maintained while the leg is swung outward sharply (D) causing corresponding inward rotation of thigh (E) to point of resistance The inverted and flexed thigh is then brought down into full extension and abduction as one movement (F) The degree of abduction should then be increased to slightly beyond normal limit as gauged by normal side to secure slight coxa vara position Movements D and F should be sharply done as they have for their purpose not only correction of deformity (outward rotation of shaft and coxa vara respectively) but impaction in the corrected position as well

extreme importance in aiding the maintenance of position and in obviating the slow healing of an anatomical replacement has been satisfactory

Following the reduction by either method, with the leg held in the position in which it is to be immobilized, mensuration and the so-called Leadbetter test for adequate reduction are made. Measurements between the anterior superior spines and the tips of the internal malleoli on the two sides determine whether or not all shortening has been corrected. The Leadbetter test consists in resting the heel of the foot of the affected

These two seem to be the most acceptable. Operative treatment will be briefly discussed after the closed treatment has been fully considered.

*Immobilization*—This is ordinarily accomplished by the use of the plaster spica, of which there are two types (Fig 366). The Whitman spica immobilizes the pelvis by making it continuous with the chest wall, therefore preventing tilting away from the

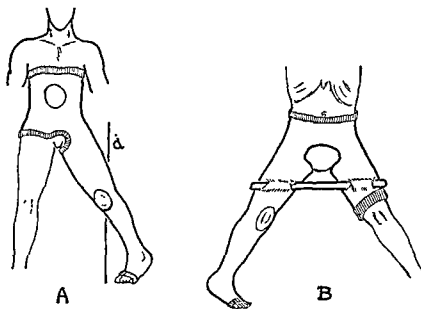


Fig 366—Two types of plaster spica. *A*, Whitman spica. Includes both anterior superior spines the thorax to the axilla, and the affected leg to the toes. The normal leg is completely free. The affected leg is in slightly beyond normal abduction, inverted so that the patella looks inward and upward at an angle of about 40 to 45 degrees, and the hip is in slight hyperextension. This hyperextension makes it necessary to have the plaster-encased leg extend beyond the edge of the bed (*a*) as shown. The knee is in very slight flexion. If reduction has been properly carried out there should be no strain on the knee or ankle in plaster. The chest portion of the spica is essential to prevent tilting of the pelvis with loss of abduction.

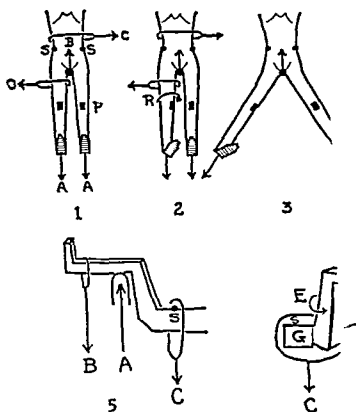
*B*, Double spica designed to immobilize hip adequately without limiting chest movements and allowing some degree of waist flexion for semi-sitting etc. The normal leg is in full abduction, the affected one in the same position as the Whitman. The pelvis is fixed by the double abduction so preventing tilting with loss of abduction. A cross bar incorporated in the plaster safeguards rigidity and aids in nursing (lifting, turning etc). The sound leg has a free knee, leg and foot. The advantages of this over the Whitman are highly theoretical under adequate nursing. If nursing care is sketchy it is probably preferable. Under adequate care, it is not as desirable. (See text.) Either spica may be put on over stockinet with felt pad protection for bony points, or cotton wadding padding. The former is probably preferable. (See text.)

side on the flat palm of the operator's hand without other support. If the torsional deformity has been adequately corrected and if the fragments are locked in the corrected position, the foot will remain upright. If either correction or locking is deficient, the foot will roll into the outward rotation characteristic of fracture of the femoral neck. The test is very definitely worth while.

Other methods of closed reduction are described and will be briefly referred to later.

affected side which would produce adduction and nullify the reduction (Fig. 367). It leaves the sound leg and thigh in complete freedom but restricts the chest movements. It is mechanically extremely effective if adequately applied. The double spica has the theoretical advantage of leaving the chest movements without restriction, but it ties up the hip on the sound side and is less certain to prevent tilting of the pelvis unless both legs are in extremely wide abduction.

one in which normal anatomy has resulted in progressive  
This elimination of a shearing strain is of weight b





This is a more awkward position than that secured in the Whitman spica and is I believe just as uncomfortable for the patient.

If there should be real pulmonary threats in the way of severe bronchitis (acute or chronic) asthma or marked emphysema the double spica has a definite advantage. Otherwise the Whitman spica is probably more desirable.

It will be noted that a window is provided in the abdominal portion of the Whitman spica which allows for more freedom in abdominal respiration for comfort after eating and in the presence of slight disten-

pads under the stockinet on either side of the area to be protected but not over it. The latter method is preferable. The points to be guarded are the sacrum and vertebral spinous processes the anterior superior spines and iliac crests the anterior sharp edge of the tibia the malleoli the dorsum of the foot and the heel. Where the Whitman spica encompasses the chest wall, a wide band of felt or a double layer of buliard table cloth is of advantage.

The skin should be well dried and profusely powdered before the application of the stockinet or wadding.

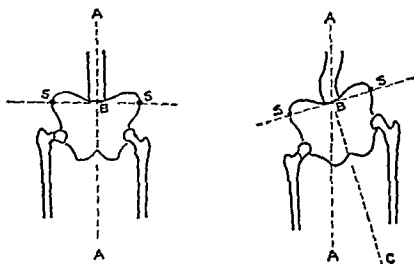


Fig. 367.—Illustrating the principle of gaining abduction by tilting of the pelvis on the fixed leg instead of abducting the leg on the fixed pelvis.

*Left.* Normal position of pelvis and spine. Pelvis is level, anterior superior spines on same level. Legs in neutral position as regards general body axis. *A*, Longitudinal axis of pelvis coincides with body axis. *Coxa vara* in fractured right femoral neck.

*Right.* Pelvis tilted by pulling down on injured side or pushing up on sound side or both. Legs are still in neutral position as regards general body axis but actually in abduction on right and adduction on left in respect to pelvis axis *BC*. Abduct on right correcting coxa vara.

on and for ventilation. In both spicas a window is cut over the patella in part to prevent pressure but principally so that free motion of the patella through voluntary contractions of the quadriceps can be carried out without difficulty.

In either spica the knee should be in slight flexion (from 5 to 10 degrees) and the hip on the affected side in hyperextension.

Either spica should be applied with adequate protection for points of pressure. This can be accomplished by snug application of cotton wadding under the plaster or the patient may be encased in stockinet and pressure points protected by the use of soft felt

The application of a plaster spica is erroneously looked on as a simple and easy procedure. It is frequently turned over to some subordinate with little or no supervision. It is a waste of time and a positive threat to the patient unless it is accurately and relatively comfortably applied. It is frequently blamed for difficulties which are due purely to the lack of care or skill in its application. If one is going to treat these fractures successfully one must know how to apply a spica properly and must see that it is so applied.

**Course and Nursing.**—The course in these cases is to be sure prolonged. It is

the rare case in which there is adequate healing by the end of eight weeks although the idea that the spica should routinely be removed at that time is quite prevalent. It is usually from twelve to sixteen weeks and frequently longer before it is safe to remove it even when healing has been progressing satisfactorily. It has been said that if all patients were kept in plaster adequately reduced and immobilized for from six months to a year there would be about 90 per cent of bony unions in the survivors of the ordeal. The mortality would of course be tremendous and prohibitive but the principle involved is sound. The problem really resolves itself into maintaining accurate position and immobilization for a long enough time and devoting further efforts to guarding against the Damocles sword of threatened mortality. These efforts comprise an adequate care of any intercurrent or coincident disease as would be given were the patient not suffering from a fracture and attention to the patient's general state of health.

The majority of the fatal issues may be grouped under two heads—one group comprising the pulmonary complications (so called hypostatic congestions and pneumonias, pulmonary emboli and pulmonary infarctions due to intrapulmonary thrombosis followed by pneumonitis) and a second group characterized by cerebral symptoms and increasing general debility with disorientation, mental apathy and deterioration slowly passing into stupor, coma and death. The first group are commonly combined under the term hypostatic pneumonias but are with the exception of the clear cut embolism cases probably for the greater part intrapulmonary thrombosis with infarctions of the lung and secondary pneumonitis. There is no more to be done at present for the embolism cases than is done to prevent embolism in the course of surgical conditions in general. They occur as frequently in non-immobilized patients as they do in the immobilized ones. Whether the other lung complications are hypostatic or thrombotic is of academic interest. The point of importance is that in either instance they are the result of circulatory factors. These patients are in general elderly with a minimal circulatory efficiency efficient largely because of their muscular activity in their daily life.

Following injury whether they be in plaster or between sand bags if they are kept still in bed their circulatory activity approaches the stagnation point. Positional or hypostatic congestion with edema may then occur—in subcutaneous tissues as well as in pulmonary tissue. Thrombosis in venous channels apparently requires the double factor of relative circulatory stasis and some factor as yet not clearly defined leading to increased tendency to blood coagulation in the patient. Studies by Bancroft and his associates have revealed many interesting facts in this connection. In those bedridden patients in whom this factor is present thrombosis may occur. In either instance the indication is clear—frequent positional change and as much muscular activity as possible.

The frequent positional change can be secured with either spica by turning the patient face downward at least twice daily for one-half to three quarter hour periods by raising and lowering at intervals during the day the head portion of the bed on blocks with the Whitman spica or the head gatch in the short wisted double spica.

The combating of circulatory stasis is accomplished by putting a trapeze over the head of the patient and making him aid in his positional changes by enforcing frequent routine exercise of the upper extremities and of whatever portion of the lower extremities is free. Quadriceps contraction with patellar movements and toe exercises can be carried out on the injured side. Occupational therapy of some sort for these bedridden patients is a great help. The importance of these aids to circulatory activity cannot be overestimated. To allow an aged patient to vegetate passively in bed is to ask for trouble particularly after tissue damage which seems connected with the presence of or increase in the factor favoring coagulation of the blood.

The cases characterized by cerebral symptoms and gradual drifting out of the patient are probably similarly due to circulatory stasis and progressive cerebral thrombosis and can best be guarded against by a similar routine. A certain percentage of these cases are probably instances of fat embolism.

In patients showing the tendency to hypostatic congestion or cerebral symptoms despite the type of care just outlined the

administration of sodium thiosulfate (1 Gm in 10 cc of saline solution intravenously every other day for three or four doses repeated at intervals with a week between each series of injections) seems empirically to lessen the tendency in some cases strikingly so. The mechanism of its action is far from clearly understood although it is presumably concerned with lessening the facility of blood coagulation. In a wide acquaintance with its use and action I have never seen any untoward results follow its administration nor do I know of any in the experience of others. And while its use is purely empirical it produces apparent results in a high enough percentage of cases to make it clearly worth while.

Next in importance to attention to the patient's circulatory status comes care of the skin. The skin must be kept clean and dry. That means cleansing with soap and water then thorough removal of the soap followed by the use of alcohol and some form of drying powder used lavishly. It also means frequent slight changes in position in addition to the turning of the patient and protection from all plaster edges by adequate binding of the latter. Powder should also be kept sifted down through all the apertures in the spica to keep the skin beneath as dry as possible. If redness of the skin appears at any point exposure to dry heat protection by soft felt around but not over that point and frequent powdering will avoid progression to actual ulceration. Frequently skin complications develop because the plaster is so applied that the patient is constantly uncomfortable and keeps trying to shift around inside the spica with resultant rubbing.

Apart from these nursing problems the care of the patient resolves itself into observation and treatment of the fracture. Roentgenographic observation subject to the same comments as made previously should be made weekly. This is for two reasons—first for evidence of aseptic necrosis partial or complete of the head and second for absorption at the fracture site with resultant loss of position. This latter occurs in about 90 per cent of cases. The former depends on the amount of circulatory damage sustained at the time of injury or due to secondary thromboses. In the first event it means a prolonged period of immobilization or re-

course to operative measures. In the second instance it means a change of plaster with regaining of the lost position. It is a vital mistake to remove plaster indiscriminately and routinely at the end of eight weeks and to decide that non union is inevitable and has in fact occurred. If there has been no evidence of either necrosis or absorption the best plan is to bivalve the plaster at the end of eight weeks have the patient lifted out and a roentgenogram made while the position is manually maintained and the bivalved plaster replaced until the films are seen. If as is the case in the minority of successful cases position and healing are satisfactory the plaster can be removed. If not either a new spica is applied in accurate position and kept on for four weeks before another similar check or else some other form of treatment open or closed is substituted. Many patients with adequate plaster and adequate nursing can be kept in the cast if need be for from twenty to twenty-four weeks.

Assuming that the treatment has been successful and that the cast has been removed in from eight to twenty-four weeks with roentgen evidence of satisfactory healing the patient is given massage to the calf and thigh muscles heat—either by lamp or diathermy—and if possible some muscle stimulation using the Smart coil or sinusoidal current and the leg gradually brought into adduction. Active motions within pain limits of knee ankle and hip are instituted—short periods frequently repeated (such as from three to five minutes every hour). These can be passively aided by a loop of bandage beneath the sole of the patient's foot on which he can pull to aid dorsiflexion and a sling under his knee with the rope through an overhead pulley to his hand with which he can aid flexion of the knee and hip. By the end of a week he is in a wheel chair and a walking caliper can be applied (Fig. 389). He then starts standing and soon walks with crutch support substituting a cane if and when possible. It is important to check the caliper carefully to see that it fulfill the conditions noted in the figure. The periods of standing and walking should again be short but frequently repeated. When the upright position is first assumed it is of great advantage to bandage the patient's

legs to the knees with an Ace or some other elastic bandage and to maintain this passive circulatory support for a period of some months to minimize swelling when the legs

monthly roentgen check is made for evidence of maintenance of position and progress of healing. Healing progress is denoted by decreasing clarity in the line of fracture,

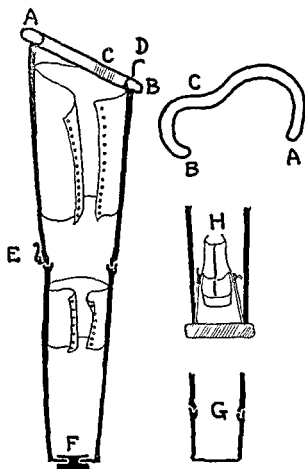


Fig. 368—Caliper splints. The illustration shows a well-designed caliper. The ring open anteriorly is slanted so as to come beneath the anterior superior spine at A but above the level of the trochanter tip and to escape impact on the pubic bone (D) at B by at least 2 fingerbreadths when the patient's weight is resting on the splint. It is indented at C so as to dip in under the tuber ischium. When patient's weight is on the splint, it should be impossible to get the finger between the tuberosity and the ring. A knee joint with a lock that can be controlled by the patient through his clothes should be exactly at the knee joint axis of motion. The leg is held in the splint either by laced leather cuffs as shown or by straps in front with circular flat metal bands incorporated in the splint behind. The foot end of the splint is fastened into sockets in the heel of the shoe or may be fitted with an ankle joint as shown in G, the lower end being riveted to the instep of the shoe. The proper length is such that when the patient's weight is on the brace, the heel just rests on the shoe and the ring is tight against the tuberosity. If too long the heel tends to pull out of the shoe. If too short the tuberosity does not rest on the ring and the neck can shorten until it does. The upper ring may be made closed but the anterior portion tends to interfere with sitting. The knee joint is flexed in sitting and locked in extension in weight bearing. When the non weight bearing type of caliper is desired it is made longer than the leg and terminated in a rubber-covered bar (H). By means of buckles on the sides of the shoe and straps attached to the end of the brace moderate traction can be maintained. A raised sole and heel is worn on the other shoe. These points are important. Many well reduced and primarily healed fractures lose position gradually on braces which do not support because they do not fulfill the requirements indicated.

are dependent. As soon as the patient can be helped into a tub under water exercise for knee, hip and ankle is of great help. A pool of course is better still. Progressive exercise and ambulation are practiced and

increasing density of bone and the presence of trabeculations crossing the fracture line. It is only when this trabeculation is quite apparent across the fracture region, after the fracture line has lost its identity, that

brace support should be removed and walking without the brace at first with crutches within a week or two with a cane and as soon as possible without a cane should be instituted. The period of brace support varies of course. It usually runs between four and six months at a minimum and may be needed for a year as indicated by the roentgen check. Crutches without actual weight bearing on the affected leg may be used instead but with the obvious disadvantage that without actual weight bearing the callus or grizes much more slowly and trabeculation is apt to be delayed. The purpose of the brace is to allow weight bearing but to prevent shortening by collapse of the unorganized callus. Many surgeons prefer to substitute for the caliper brace period a similar period of walking with crutches without bearing weight on the affected leg. For a reliable and trustworthy patient, this is probably preferable to the brace.

**Other Closed Methods**—The reduction of the fracture in whole or in part has been varied by the use of mechanical aids and the fixation has been varied with the idea of allowing freedom of motion at the hip during the period of fixation.

The Ruth method of reduction employs the same mechanism on the flexed thigh as previously described under the Leadbetter procedure except that it is not a 'one man job' in that outward traction on the thigh is exercised by an assistant (as in the modified Whitman method) and the force exerted on the leg is made by a second assistant. The mechanism is essentially the same. The reduction is followed by the application of a short double spica as described in figure 366 except that the sound leg is included to the ankle and that a period of three weeks between reduction and immobilization is allowed with the patient in traction in bilateral wide abduction with a lateral pull by a sling around the thigh. There seems to be little if any advantageous reason for this intervening period.

The Wilkie procedure is essentially one of immobilization and must be preceded by adequate reduction. Its chief feature is immobilization by full bilateral abduction in version maintained by two leg boots of plaster and a cross bar (roomstick) at the feet or ankles. It allows the patient to sit up

that is as much and as comfortably as wide bilateral abduction and straight knee will permit and is designed principally for ease of application and for its effect on the mortality factors. The rigidity of fixation is somewhat questionable and if any absorption occurs it is precarious. The knee strain if abduction is fully maintained is considerable. It can be used if adequate spica immobilization is impossible for any good reason (soft part damage, lack of facilities, lack of ability, patient's refusal) but is essentially a much less efficient substitute.

Two common methods in use depend for the abduction and traction phases of reduction on tilting of the pelvis (Fig. 367) employing the well leg traction principle of Hoke. In one the Carl Jones splint is used. In the other the Roger Anderson splint is used. In each instance pull downward is exercised on the injured leg and push upward on the sound leg thereby tilting the pelvis. As the use of these methods is not advocated in fractures of the femoral neck of the intracapsular type their description is deferred to the discussion of the intertrochanteric and base of the neck fractures to which they are applicable.

In those who are essentially bedridden before the time of accident or who are so aged and senile that it is felt that they would never walk again even if a satisfactory healing of the fracture were secured there seems no logical reason for carrying out the arduous course of closed reduction and immobilization. The indication in these cases if it has been decided that internal fixation is contraindicated by reason of lack of facilities or by reason of the patient's condition is to make the patient comfortable during the period of pain and spasm. When he can lie in bed or sit in a chair and undergo the usual care with no discomfort from the hip the treatment has fulfilled its purpose. The idea of this type of treatment is not carried out by sand bag immobilization. It is best carried out by balanced traction suspension until such time as the patient is comfortable without it. Adequately applied it will keep the patient comfortable and will greatly simplify nursing. Neither of these statements is true of sand bag treatment. The method is described under the treatment of the following group (intertrochanteric frac-

tures). It is, of course, only under those circumstances where the relatively conservative procedure of closed reduction followed by internal fixation through an incision along the lateral trochanteric region cannot be used, for one reason or another, that purely closed methods with immobilization are today justified and that the above advice as to the bedridden and senile patient holds good.

If, following adequate reduction and maintenance of reduction for the prolonged period indicated, non-union with or without

terion on which to base a decision. Many patients with absolute non-union, even with absorption, showing 1 to  $2\frac{1}{2}$  inches of shortening, and with marked limp may obtain a practically painless condition of the hip with a satisfactory range of motion under either of the two methods first mentioned. Before deciding between the conservative and the operative handling of these "x-ray failures," one must consider the patient as an operative risk, his temperament, his economic status, the quality of surgery which is available for him, and the question of what will



Fig 369—Patient in thigh and leg skin traction in Thomas splint and Pearson leg piece. Compare with figures 373, 376, and 377 for diagram of details

absorption has occurred, or if, because of one factor or another, it has been impossible to carry out treatment and non-union is the result in a patient who has to be up and about, a decision must be made as to the proper treatment. Long-continued non-weight-bearing traction brace support (Fig. 368), long-continued crutch support with initial slight but gradually increasing weight bearing, operative reduction and internal fixation by one means or another, and an operative reconstruction procedure are the alternatives which present themselves. The roentgenogram should not be the sole cri-

terion on which to base a decision. Many patients with absolute non-union, even with absorption, showing 1 to  $2\frac{1}{2}$  inches of shortening, and with marked limp may obtain a practically painless condition of the hip with a satisfactory range of motion under either of the two methods first mentioned. Before deciding between the conservative and the operative handling of these "x-ray failures," one must consider the patient as an operative risk, his temperament, his economic status, the quality of surgery which is available for him, and the question of what will

**Operative Treatment.**—Operative treatment of an intracapsular fracture must be considered under two heads—that of the

primary operative treatment of the fresh fracture and that of the late operative handling of the ununited or malunited fracture

**Primary Operative Treatment**—Many methods for the primary operative treatment in these cases have been developed. I have included in this class all procedures which are accompanied by actual operation. Some of them combine closed reduction for the fracture itself with open exposure of the trochanter for purposes of fixation or of providing circulation or both. Some of them call for postoperative immobilization as in the purely closed methods. Others allow of early mobilization of the extremity or early mobilization of the patient or both. In order to evaluate adequately the various methods in use it might be wise to look into the justification for operative methods. The matter may be regarded from three viewpoints—that of mortality, that of bony union and that of function of the extremity.

**Mortality**—Elderly patients with intra capsular fracture die because of being kept quiet and immobilized in bed, the resulting circulatory stasis leading to various fatal complications, pulmonary and cerebral. To be fully efficient operative treatment must allow mobilization of the extremity as well as of the patient. There is no question but that the mortality is lowered and lowered tremendously if this can be done, provided the operation as done does not add a mortality rate of its own.

**Bony Union**—If the prospects of bony union are to be enhanced, the improved chance must not be grimed at the expense of an increased mortality. Increased chance of bony union results from more accurate reduction from prolonged immobilization of the fracture site and from rapidity of restoration of circulation lost by reason of the trauma. To be fully efficient on this score operative treatment must provide accurate reduction, prolonged immobilization of the fracture site and opportunities for restoration of circulatory loss without immobilizing the extremity or the patient.

**Function of the Extremity**—Joint function, muscle strength and bony anatomy are the three factors involved in the function of the lower extremity. Mobilization of the joints, development of muscle power and ac-

curate restoration of bony anatomy are demanded of operative treatment if it is to be fully efficient.

On the basis of these three criteria, the open methods used as the primary treatment of the fresh fracture will be discussed and evaluated.

**1 OPEN REDUCTION OF THE FRACTURE**—Developed largely through the efforts of Smith Petersen of Boston, this procedure has taught us a great deal about fractures of the femoral neck. Indeed, I believe that Smith Petersen's influence in developing sound treatment of this fracture ranks with that of Whitman. They represent the two outstanding influences in this field. The actual pathologic condition of the fracture site, the inadequacy of ordinary roentgenography, the mechanism of adequate reduction and the basis of rigid fixation have all been clarified and further developed on the basis of Smith Petersen's contributions.

Within the last few years this has led to a conviction that adequate reduction and fixation can be secured in the vast majority of cases without the necessity for open reduction of the fracture itself. Open reduction of these fractures is a formidable procedure that must be limited to selected cases in the hands of particularly qualified surgeons.

**2 CLOSED REDUCTION WITH INTERNAL FIXATION**—This is today the accepted method of primary treatment when it can be done. Reduction is accomplished by either of the methods advised in the section on closed reduction and after adequate roentgenologic check to prove the position, fixation is inserted through an incision over the lateral aspect of the trochanter without exposing the fracture. For the method to fulfill its purpose, it must dispense with postreduction plaster immobilization and must allow the patient to be active first in bed and later in a chair and walking on crutches. There is no justification in getting the patient up in a chair or on crutches within a few hours or a day after the fixation unless his pulmonary or circulatory status is critical. There is nothing in particular to gain by such precipitate action except to shorten the stay in the hospital by a few days. If the patient is kept in balanced suspension in bed, moving himself about and moving the extremity in suspension for a

week to ten days and then started on chair and crutches without weight bearing on the affected leg the purpose of the treatment is fulfilled. Incidentally, it is better to use crutches and no weight bearing on the affected leg in these cases than it is to use a brace. The torsional strain occasioned by a brace before bone healing occurs is a disadvantage. A particularly feeble or unreliable patient may however require the use of a brace.

Many methods of fixation have been devised. Fixation by the flanged nail of Smith

use is that employing multiple Kirschner wires either directly through the skin or through an incision over the outer trochanteric aspect. This method is inadequate since the multiple Kirschner wires will not stand the strain of muscle pull without bending, much less the strain of active exercise. Corvair deformity and shearing strain result. Because of this multiple wires which are of more rigid construction such as those of Ransohoff and Telson have been used. The insertion of such wires is less difficult than the insertion of the Smith Petersen

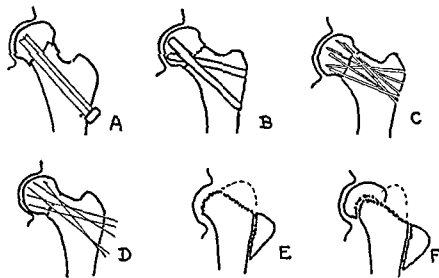


Fig 370—Common operative procedures in fracture of femoral neck. A, Smith-Petersen flanged nail. Used in conjunction with either open or closed reduction of the fracture itself. B, bone pegs. Either the double peg or a single one may be used with either open or closed reduction of the fracture itself. C, multiple drill holes from trochanter through neck fragment into head. Usually used in conjunction with closed reduction of fracture. D, multiple Kirschner wires directly through skin or openly inserted following closed reduction. E, Whitman type of reconstruction following old ununited fracture. Head is removed, smoothed neck fragment placed in acetabulum and trochanter with its muscle attachments transplanted as indicated. F, Brackett and Magnuson type of reconstruction. Head retained, followed out to form cap sitting on top of rounded-off end of neck and trochanter transplanted as indicated. Thrust is directly upward into head instead of cross strain. (Compare Fig 361 diagrams 8, 4 and 5.)

Petersen is mechanically the most advantageous in that its three thin blades, radiating fanlike from a common center, provide fixation with a minimum of bone damage and are an effective bar to rotation of the fragments on one another, even though some absorption occurs about the pin. It is essential for the pin to be placed at an oblique angle and for the fixation to be in slight *corvair* position. The procedure calls for impaction of the fragments as the nail is introduced, since the driving of the nail tends to separate the fragments a little.

Another method of fixation in common

pin but I see no particular advantage in their use. However, if they are rigid enough and accurately placed and if impaction is practiced they may give adequate fixation. Penetration of the joint cavity and even of the pelvis may result unless particular care is exercised in making a roentgenographic check. The Smith-Petersen pin is generally considered as preferable.

The use of lag screws for the fixation, such as that of Henderson, has been practiced. In theory, rigid fixation and a constant pull approximating head to neck are its advantages. Since the lag screw is embedded in



the cancellous head and since it does much more damage than the Smith Petersen pin in its insertion it seems to have its theoretic advantages counterbalanced by practical disadvantages.

Bone pegs from the tibia (Albee, Wilson) or from the greater trochanter (Jones) have been used. As a primary procedure they fail to fulfill the requisite of allowing the patient and the limb to be mobilized. Their theoretic advantage lies in their possible aid to reestablishing circulation but that they do this is far from being shown. They are therefore not to be recommended for a primary procedure.

completed fixation is essential. This means that for the employment of this method of fixation a *sine qua non* includes facilities for taking adequate roentgenogram in the operating room and of seeing them at each step before proceeding to the next one.

It is impossible at present to advise the use of any one protractor or range finder or method of determining the course of the fixation. Many are in existence, and many are being developed. In general the simplest one with which results can be obtained is the best. No one of them is sufficient to eliminate the absolute necessity of roentgenographic control.

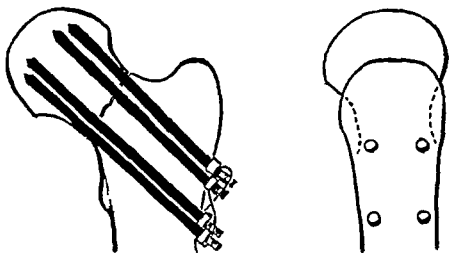


Fig. 371—Austin Moore pins. The four pins are placed so as to impinge on the neck cortex above and below. A nut on the end of each prevents further penetration. The four pins are wired together; the tension of the wire tending to prevent extrusion of the pins. The drawing at the right shows the placing of the pins in the lateral plane. Caruthers, of Cincinnati, uses three somewhat similar pins of specially tempered steel, placed parallel, one at the upper border of the neck, one at the lower border and the third one midway between, all of them lying in the medial position in the lateral view. They are inserted at as oblique an angle as possible with the shaft below the trochanter.

For all these methods of fixation without the use of open reduction numerous methods of protraction and range finding have been devised for accuracy in placement of nails, screws and wire. The preliminary insertion of a wire over which a perforated model of the Smith Petersen nail is to be threaded is used. It endangers at times complications in the removal of the wire if bending occurs. No matter what protractor or range finder is used, no matter what anatomic landmarks are used and whether or not preliminary wire insertion is employed, an adequate anteroposterior and lateral roentgenographic check of the reduced fracture of the started nail, wire or screw and of the

In the author's experience following the advice of Smith Petersen, the use of a Kirschner wire passed  $1\frac{1}{2}$  inches below the ridge on the greater trochanter representing the attachment of the vastus lateralis at exactly 45 degrees to the shaft of the femur midway between the anterior and posterior borders of the bone and parallel to the table (with the thigh in full extension and with 15 degrees of internal rotation) has been all the guide needed for accurate placement of a Smith Petersen nail. Roentgenograms of a wire so placed will give definite information as to just how the nail should be placed. The lateral view is of course essential. Before driving the nail in

it is well to insert the wire far enough to penetrate the acetabulum for a short distance. This serves to keep the head of the femur from shifting its position as a result of mallet blows on the nail.

One further note of warning—it has been too readily assumed that the so called closed pinning of a fractured femoral neck is a simple harmless procedure. Nothing is further from the truth. It should be done under rigid asepsis as for any other operation. And its accomplishment does not mean that the patient can bear weight any sooner with safety than he can under fully closed methods.

To summarize it may be said that at present the method of choice in the treatment of an intracapsular fracture of the femoral neck is closed reduction adequately checked roentgenographically and followed by internal fixation placed through an incision over the outer aspect of the trochanter. The simplest method found feasible for determining the direction of the pin should be used and the insertion of the fixation should be checked by anteroposterior and lateral roentgenograms at its beginning during its course and at the close of the procedure. The Smith Petersen nail still offers the most efficient mechanical method of fixation. The post reduction course should not be too assiduously rushed particularly as regards weight bearing. The procedure should be done under rigid surgical asepsis. It will allow of early mobilization of the extremity and of the patient with lowering of the mortality rate and earlier and better functional results and the results as to bony union will be enhanced by reason of the prolonged fixation of the fracture site which it makes possible.

It may well be that the drilling of multiple fine holes from the trochanter into the head (Bozsan) after the reduction and fixation may affect the chances of bony union by aiding vascular rehabilitation. It should be given adequate trial and may help to avoid the late degenerative changes which occur even when bony union has been secured. If practiced as a primary procedure after closed reduction but followed by plaster immobilization instead of internal fixation it has all the mortality and functional risks of plaster treatment.

*Secondary Operative Treatment—*  
1 WHEN CLOSED REDUCTION AND IMMOBILIZATION HAVE FAILED AFTER A REASONABLE TIME—If the position is good but union has not occurred fixation without open reduction by means of the Smith Petersen nail combined with the use of the drilling as previously mentioned (Bozsan) may be effective.

Open reduction with the nail fixation and open reduction with use of a bone graft through the trochanter and into the head may be used the latter followed by plaster immobilization.

The same comments apply to these methods as previously made.

2 WHEN CONSERVATIVE METHODS AFTER FAILURE OF UNION HAVE BEEN UNSUCCESSFUL—The reconstruction operations described in figure 370 are indicated. If these are unsuccessful arthrodesis of the hip may be indicated if the patient can stand it. In addition to these three other procedures should be mentioned. One is the reconstruction devised by Colonna based on the Whitman reconstruction but designed to hold more adequately a smooth covered surface within the acetabulum. In this procedure the muscle attachments are removed from the greater trochanter, leaving smooth periosteum and the trochanter itself is placed in the acetabulum the detached muscles being attached to the shaft well below and serving to keep the trochanter pulled into the acetabulum. A second procedure is that used by Watson Jones of Liverpool for the old and feeble patient who may not be able to stand either reconstruction or arthrodesis. It consists in fixing both the fracture and the joint by driving a special large pin of the Smith Petersen type through a lateral incision from the trochanter through the acetabulum giving mechanical fixation capable of limited weight bearing.

Finally, in place of reconstruction or of arthrodesis a McMurray osteotomy may be performed. It will frequently relieve pain and give a good hip. Many surgeons prefer it to the rigor of reconstructive or arthrodesis procedures.

*Prognosis in Intracapsular Fracture—*  
The mortality rate with the use of closed reduction and plaster as determined by a cross section study of the country at large is

high. In individual localities it varies with the efficiency with which both the fracture and the patient are treated, with the size of the series of reported cases and with the nature of the institution and the type of patient (private clinics on the one hand and municipal and county hospitals on the other, are the two extremes). The average by and large is about 20 per cent. As low as 7 per cent has been reported (Stearns), and as high as 35 or 40 per cent is found

5 and 10 per cent. Under closed reduction with fixation through the lateral incision the mortality has been much further reduced, being reported as zero by some groups, but less than 5 per cent certainly for all. Available statistics show variations in connection with the size of the series reported, the selection of cases and the criteria used for judging results, successes (meaning satisfactory function and bony union) being reported in from 60 to 100 per cent of cases.

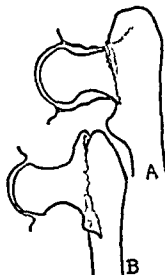


Fig 3-2



Fig 3-3

Fig 3-2.—Base of the neck and intertrochanteric fractures. Outward rotation, upward tilting and coxa vara are the characteristic deformities. It will be noted that there is but little rotatory displacement of the head. It is practically all abduction. The proximal and distal fragments maintain some connection through the fibers of the capsule in *A*, the base of the neck and through the muscle attachments in *B*, the intertrochanteric. The lesser trochanter may be split off as a separate fragment and is then pulled upward and medially by the psoas. The greater trochanter may in part be a separate fragment. Such displacements of the trochanters as exist are of little or no significance. They are adequately cared for by flexion of the hip during treatment.

Fig 3-3.—Result of traction with abduction and internal rotation in intertrochanteric and base of neck fractures. The intertrochanteric fractures are adequately reduced by traction in slight or moderate abduction, probably because of the attachments which remain between the two fragments noted in figure 3-2. Pressure of the trochanter against the acetabular rim for rigid fixation purposes is not needed and therefore wide abduction is again unnecessary, as absorption at the fracture site is not ordinarily seen.

in some institutions. Under adequate care satisfactory function with bony union occurs in between 60 and 70 per cent of surviving patients. Under inadequate care close to 100 per cent failure of union has been reported in a large municipal hospital in one of our larger cities in a series of over 80 cases.

The mortality rate of primary operative treatment when open reduction is practiced in adequate hands is definitely lower than when closed reduction is practiced by the same surgeons or groups, running between

The average in a large series in good hands is probably about 75 per cent.

At present it can be said that operative fixation following closed reduction which will allow of early active mobilization of the patient and his extremity greatly reduces the mortality figures and through the prolonged immobilization of the fracture site it definitely increases the percentage of satisfactory results.

Regardless of the method of treatment used (whether closed reduction followed by plaster, closed reduction followed by

ternal fixation through a lateral approach, or open reduction with internal fixation), in about 15 per cent of the patients showing bony union, degenerative changes in the head develop subsequently. Since these changes frequently do not make themselves clearly evident by x-ray for from one to three years after the fracture and since they frequently are accompanied by progressive pain and stiffness in the hip, the prognosis

This opinion is held because, while Christopher's series showed no cases in which non-union or subsequent deformity occurred and while others, with small series, have had the same experience, the author has seen 4 cases so treated in which absorption at the fracture line with resultant deformity and non-union has resulted. When the procedure of internal fixation through the lateral approach for any reason constitutes a real risk

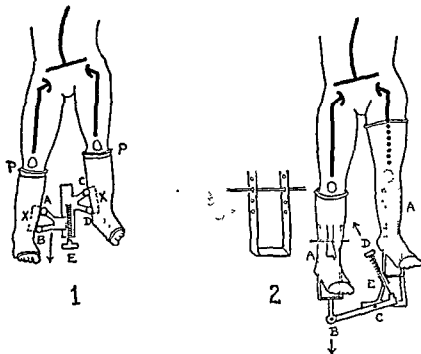


Fig 374—"Well leg traction" (See figure 367 for principle involved) 1, Carl Jones splint. The central tube has a fixed lateral arm attached to or incorporated in the plaster on the leg on the sound side by means of a plate pivoted (adjustably) at C and D to allow the proper angle of the plate with the side. The arm on the injured side is moved on a worm rotated by handle E. P indicates heavy felt padding of the circular plaster which is very necessary. The plasters end below the knee. 2, Roger Anderson splint. A pin is put through the tibia on the injured side and incorporated in a circular plaster ending below the knee. The yokes A are then incorporated in the plaster, the circular on the sound side reaching to the region of the upper third of the thigh. The yoke on the injured side is perforated (small inset) to catch the pin. By reason of the pivots at B and C, progression of the traction screw D through its socket E (fixed to the arm on the sound side) in the direction of the arrow exerts downward traction on the yoke on the injured side. A spring keeps tension on the traction screw.

in hip fractures and the reports on results should take this fact into consideration.

When the fracture has resulted from a blow against the trochanter, with a resultant *coxa valga* position in impaction, the prognosis is in general excellent for bony union. Reported excellent results in such cases by the use of a short (knee length) abduction spica, elevation of the opposite heel and ambulatory weight bearing from the beginning (Christopher) without other fixation are increasing in number, but in the author's opinion, pinning should be done if possible

to the patient, on the other hand, the ambulatory method without internal fixation may be a justifiable procedure.

#### BASE OF THE NECK AND INTERTROCHANTERIC FRACTURE

In contrast to the intracapsular type of fracture, bony healing in fractures of the base of the neck is the rule, while it is almost without exception in intertrochanteric fractures (Fig. 360, 3 and 4). The mortality rate on the other hand, is as great as in the



Fig 3\*5—Patient in thigh and leg skin traction in Thomas splint and Pearson leg piece. Compare with figures 3\*6, 3\*7 and 3\*8 for diagrams of details

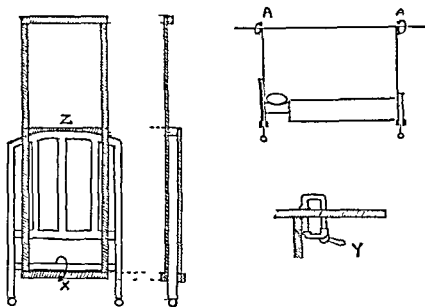


Fig 3\*6—Details of easily constructed bed frame designed for rapid assembly. Oak strips 21 inches by  $\frac{5}{8}$  inch and of desired lengths 11 and 1 foot units in one piece as per diagram fastening by single clamp (1). All screw construction in head and foot units. Desired lengthwise and crosswise pieces are fastened by a clamp working by a single throw of lever (2) and adjustable to all thicknesses up to 4 inches (Colt eccentric clamp no. 1—at any large hardware store). Piece resting on head or foot rail is curved to fit it.

intracapsular type. This is in accordance with the age group of the patients—about the same as that of the intracapsular type. The convalescent period is distinctly shorter

in that from six to eight weeks usually sees bony union sufficient to allow of brace support, and such support rarely needs to be worn for more than three or four months. There is a tendency for the healing callus to remain soft enough to undergo gradual compression if weight bearing is allowed as soon as bony healing is apparent, with resulting *coxa vara* deformity. The signs and symptoms are identical with those of the *intracapsular type*

the abduction needed is much more moderate, since fixation of the trochanter against the acetabular rim is not necessary. The criterion is traction and abduction sufficient to give normal length and nursing ease, plus the inversion. The period of plaster treatment has been indicated, and the criteria for removal of plaster are the same as in the *intracapsular fractures*, plus the appearance of profuse visible callus in the *intertrochanteric type*. The *splitting off of the trochanters* in

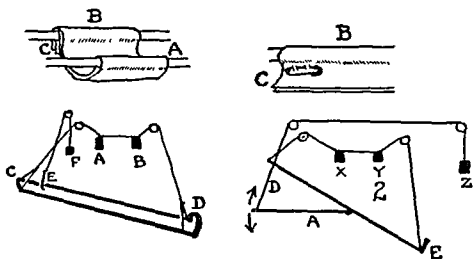


Fig 377—Details of suspension for skin or skeletal traction Thomas half-ring splint and Pearson leg piece. Upper left Flannel supporting slings for splint and leg piece—doubled

Upper right Method of fastening with safety pins—easily adjustable, no interference with x ray

Lower left Suspension with straight knee Suspending weight split into two increments for ease of adjustment—sliding weight A toward distal pulley raises distal end of splint, sliding it proximally from the pulley lowers the distal end of splint. Same holds true of increment B as regards ring portion of splint. Half ring splint with ring on top makes for ease of nursing and skin care. Whole ring can be used but is obviously less satisfactory. Foot piece E to keep foot from dropping into plantar flexion (weight F)

Lower right Suspension with flexed knee Hinged Pearson leg piece A attached to Thomas splint at level of axis of knee motion X and 1. Suspending weights E. Half ring on top. Rigid fastening between splint and leg piece (at D) when no active motion at knee is desired with skeletal traction or when it is not possible (as in skin traction). When motion is desired in skeletal traction rope from end of Pearson leg piece passes through two overhead pulleys to weight Z within reach of patient's hand and leg piece is left free to move at its hinge, patient's efforts at motion being aided if necessary, by manual manipulation of weight Z

**Treatment.**—The treatment differs in that the reduction is accomplished by traction in mild or moderate abduction with inversion, is always easy to accomplish and is easy to maintain.

The methods available are:

1. **MANUAL REDUCTION BY TRACTION, MODERATE ABDUCTION AND INVERSION.** The outward pull during reduction is not needed in these cases. The broad surfaces of these fractures cannot be readily impacted nor do they need impaction. The reduction is followed by the single or double spike described under *intracapsular fracture*, excepting that

some cases is a matter of academic interest, but has little or no significance as regards treatment.

2. **THE "WELL LEG TRACTION,"** utilizing the principles shown in figure 367 and employing the apparatus shown in figure 374, is quite effective in these cases. It has the advantage of allowing the patient to be up in a wheel chair early. When this method is used, the inversion must be secured before the apparatus is applied. There is no need for the care of the traction apparatus, as described later, and the care of the patient's skin is of course easier. It is to be remem-

bered that there must be very heavy padding preferably thick felt beneath the plaster boots to avoid possible pressure on the peroneal nerve

**3 TRACTION SUSPENSION IN MODERATE ABDUCTION AND INVERSION.** This is effective in these cases it is not in the intracapsular type. Skin traction as illustrated in figures 369 375 376 and 377 may be used if but little displacement exists. Skeletal traction using the Kirschner wire is preferable if much displacement is present. The wire is

present in a hernia operation. If under the conditions present infection is an appreciable risk it is the writer's opinion that there exists no moral justification for the use of skeletal traction except absolute necessity here or elsewhere. The amount of weight needed in traction is from 5 to 20 pounds or more depending on the degree of displacement and the size of the patient. The wire traction is obviously more effective in gaining and holding a position than is skin traction.

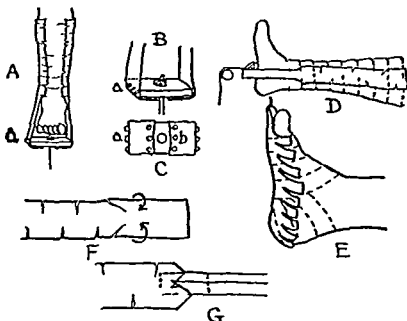


Fig 378—Details of adhesive skin traction. A Adhesive strips molded to shape of leg and kept closely applied to skin by use of woven elastic bandage. Spreader of wood just wide enough to make adhesive strips clear the malleoli (a) and as close to sole as possible to prevent torsion of straps. Traction rope held by large knot on inner face of spreader. B and C details of spreader. Adhesive fastened by thumb tacks to spreader. B is anteroposterior view and C is bottom or outside surface of the spreader. D rope from spreader passes over pulley on frame or at foot of bed. E foot piece of adhesive (see Fig 377). Dotted lines represent woven elastic bandage to keep adhesive closely applied. F and G details of traction strap. Woven elastic bandage lateral tacks to aid molding to shape of leg. Adhesive side of strap facing outward. Dotted line in G represents small strip of adhesive to reinforce the junction between folded and unfolded portions of the strap where there is tendency for plaster to rip under heavy traction.

best placed through the femur as indicated in figure 380 but may be placed through the tibial tubercle. The advantage lies with the former method since it permits the employment of active mobilization of the knee from the beginning this cannot be done if the pin passes through the tibial tubercle. The only logical reason for using the tibial tubercle is that if infection occurs about the pin the knee joint is not threatened. If the technic described in figure 380 is employed there should be less risk of infection than is

**4 RUSSELL TRACTION.** This is illustrated in figure 379. It is simple to apply, more effective than ordinary skin traction but less accurately controlled. It is less effective than pin traction. It allows of great freedom of movement by the patient and is therefore of value in nursing care. In these fractures where union practically always occurs regardless of treatment it can well be used. The maintenance of adequate inversion in this as in ordinary skin traction suspension may present difficulties. The peroneal

nerve must be closely watched (foot drop and anesthesia or paresthesia over the dorsum of the foot) and the popliteal space watched for pressure.

The internal fixation of these fractures has been developed in recent years by the introduction of the Thornton plate attached to a Smith Petersen nail and by the development of the Moore blade. These can be applied through a lateral incision after closed reduction or open reduction. The Thornton plate attaches by a setscrew to a Smith-Petersen nail and is fastened to the lateral aspect of the shaft of the femur below by

The technic of application can be found by consulting the references cited at the end of this section.

**Prognosis**—Bony union occurs regardless of treatment, in practically 100 per cent of intertrochanteric fractures and in well over 90 per cent of fractures of the base of the neck. The mortality because of the age group runs as high as 20 per cent. It is highest in plaster immobilization and is increasingly lower as activity of the patient is allowed and enforced. The anatomical result varies with the accuracy of the primary reduction, the maintenance of that reduc-

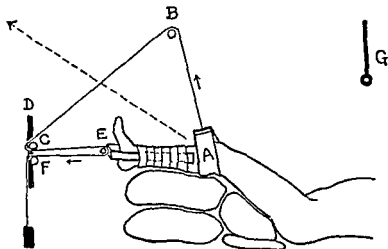


Fig. 379—Russell traction. The thigh and leg are supported on pillows. *A* is a sling underneath the knee and upper calf. From this a rope passes through an overhead pulley *B*. Skin traction is applied to the leg and incorporated in the spreader is a pulley *E*. Attached to the foot of the bed is a board holding a double pulley *CF*, or two pulleys close together. The traction cord from *B* passes through one side of the double pulley *C*, then through the pulley on the spreader *E*, and back through the other side of the double pulley *F* to the traction weight. The pull is a multiple of the weight owing to the double-pulley arrangement. The resultant of the two pulls as indicated by the large dotted arrow. Lowering the level of the pulley *CF* or placing the pulley *B* nearer the foot of the bed will alter the pull toward the horizontal. Raising the level of pulley *CF* or shifting pulley *B* toward the head of the bed will alter the pull toward the vertical. *G* is an overhead trapeze for use by the patient in shifting his position in helping him to sit more or less upright and in raising himself to use a bed pan during bed changing etc.

three or more screws. The Moore blade is a flat metal blade with a horizontal arm and a vertical arm having the same angle to each other as the neck and the shaft of the femur. The horizontal blade has a cutting edged tip and is driven into the neck as one would drive a Smith-Petersen nail and the vertical blade is screwed to the lateral aspect of the femoral shaft. The use of one or the other of these appliances is displacing the more conservative measures described above with resultant improvement in maintenance of good anatomical position and marked lowering of the mortality rate.

tion and the protection of the primary healing against the combined elements of muscle force and weight bearing tending to produce comminution until the soft callus is adequately organized. (See Fig. 361, 3 and 5.)

#### SUBTROCHANTERIC FRACTURE

This fracture occurring at the upper end of the shaft and at the base of the great trochanter is characterized by marked abduction, flexion and external rotation of the upper fragment owing to the action of the practically intact musculature attaching to the trochanters and the intertrochanteric



line The net result is a very marked angular deformity just below the trochanter usually with marked shortening The often visible and always palpable deformity by its location distinguishes it from the neck and intertrochanteric fractures It is much more apt to occur in persons between thirty and fifty years old than in those in the earlier or later decades and is usually the result of rather severe and often direct trauma In keeping

pearance of callus alone is used as a criterion for release from immobilization

This fracture in common with all fractures of the femur demands for the best emergency treatment the use of the Thomas type of splint with fixed traction Such shock or wounds as the patient shows may then be treated with minimum damage to the fracture and maximum protection to the patient

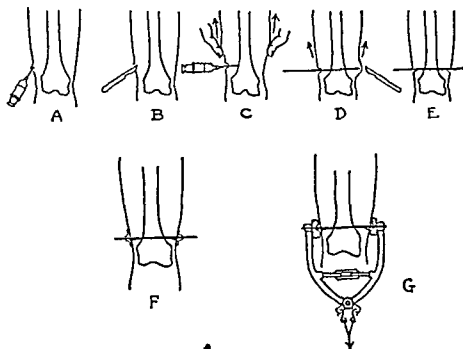


Fig 380—Technic of pin insertion Shave skin and clean with soap and water and alcohol Iodine on the field Drape adequately with sterile towels Wear sterile gloves A Skin bleb of novocain Note site picked for pin—just above the flare of the femoral condyles It avoids the joint cavity and also the nutrient vessels B quarter inch skin nick with scalpel C assistant pulls upward on soft parts on each side while novocain is injected through skin nick down to and into periosteum The upward pull is maintained until the pin is fully inserted D pin driven by hand or motor drill until it pulls skin ahead of it on opposite side Novocain bleb is then raised and second quarter inch nick made allowing pin to come through F pin is all the way through and upward pull on soft parts is released Tissues now tend to pull away from pin's inferior surface minimizing tendency to soft part pressure when traction is made F dressing Then circular piece of sterile absorbent cotton fastened to skin and to pin by collodion or rubber cement Region of pin always visible for inspection G yoke applied tension on pin made by turnbuckle piece of snugly fitting sponge rubber (sterilized) between yoke and skin Keeps dressing snug and minimizes possibilities that pin may slip from side to side

with this the fracture is most often relatively transverse The spiral and long oblique fractures from torsional strain are usually located farther down the shaft of the bone

A second characteristic of the lesion is that while it almost invariably heals with out difficulty if reduced the healing callus remains soft for a considerable length of time and abduction angulation of the upper fragment is apt to occur if the roentgen ap-

The deformity with the extreme difficulty of controlling the short upper fragment makes it essential to carry out the reduction and immobilization with flexion at the hip and knee with outward rotation of the thigh and in sufficient abduction to align the fragments The lower fragment constantly tends to drop behind the upper even when length and a normal axis have been secured and a forward lifting force has

ing The Stader or the Haynes apparatus may be similarly used The technic involved in use of the Stader Roger Anderson or Haynes apparatus can be found in the references at the end of this section

Because of the frequent difficulty in securing and maintaining adequate position by any or all of these closed methods by reason of lack of control over the short upper fragment this site of fracture offers a primary operative choice when conditions warrant The discussion of this problem with the methods of fixation will be developed under the treatment of fractures of the shaft

**Prognosis**—These fractures reduced and given time enough rarely show non union but they characteristically show slow union The period of disability runs from five months up to nine months The mortality rate is dependent on the severity of the primary violence and coincident injuries and because of the prolonged immobilization time on the same complications to a lesser degree as are seen in fractures of the neck of the femur The lesser frequency of these complications is probably in relation to the less advanced age of the average patient

#### FRACTURE OF THE LESSER TROCHANTER

Isolated avulsion fracture of the lesser trochanter occurs by muscular violence It is rare The writer has seen three cases two of them epiphyseal separations in older children and one in a young adult after fusion of the epiphysis

It is apparently of little clinical importance The diagnosis is made by means of roentgenograms after violent strain (a take-off for a broad jump in one instance) resulting in pain and swelling with local tenderness in the groin and restricted and painful hip extension The fragment is displaced upward and medially by the pull of the psoas muscle

The simplest treatment is bed rest in the sitting position with knees and hips as acutely flexed as possible and early physical therapy to the muscles in the inner upper thigh region After from ten days to three weeks depending on the amount of primary separation gradual extension is practiced aided by physical therapy and after four weeks ambulation with crutches and active exercise of the hip are started

From six to eight weeks should see complete recovery

#### FRACTURES OF THE FEMORAL SHAFT

Fractures of the shaft constitute the second great group of disabling fractures of the femur the intracapsular femoral neck being the first Under modern methods of treatment this seems unjustified if therapy is wisely chosen and adequately carried out from the beginning Only fractures of the shaft in adults will be discussed here In children the problem presented is entirely different and will be discussed later under the heading of fractures of the femur in children

In common with fractures of the shafts of other long bones the fracturing force may be either direct or indirect violence This is of more than academic importance in that direct violence is more apt to result in a transverse or short oblique fracture whereas indirect violence is apt to result in a long oblique or spiral fracture a matter which has some bearing on the method of treatment In addition in the direct violence type if compounded the fracture is usually compounded from without with considerable devitalization of the tissues in the region of compounding whereas the fracture due to indirect violence is compounded usually by penetration of a sharp fragment from within with much less bruising and contusion to adjacent soft parts

The age incidence is that of the exceedingly active period of life—active childhood and adult life before forty the majority in adults between the ages of twenty and thirty This is in a way fortunate because the patient is usually a young active individual and one in whom joint stiffening and muscle atrophy are not such threats as they are in older persons and the mortality threat of bed rest is not in evidence

It is in these cases particularly that the use of the Thomas type of splint with fixed traction as an emergency measure is of the utmost value Every hospital ambulance every hospital emergency ward and every doctor's office and automobile should be equipped with a Thomas type of leg splint and also a hinged ring arm splint (Murphy Jones) and its immediate use in actual or suspected fracture of the femur instituted

until definitive treatment is decided on. Although emergency traction is indicated in all fractures of long bones, it is so important in femur fractures that it is described here (Fig. 382). It prevents such situations as are commented on in the description of figure 393 and in general makes the ultimate reduction easier, the soft part pathology less, minimizes shock, minimizes the dangers of delay in reduction and keeps the patient remarkably comfortable. Its general adoption would constitute the biggest advance in

due to gravity distribution of the weight of the limb. It is therefore not only unnecessary to practice the inversion followed in fractures of the upper end of the femur but actually perverse. The x-ray film taken preliminary to treatment is of prime importance in that the nature of the fracture, line, the presence or absence of comminution and the exact relation and position of the fragments are extremely important in the choosing of the method to be used and the procedure for reduction.

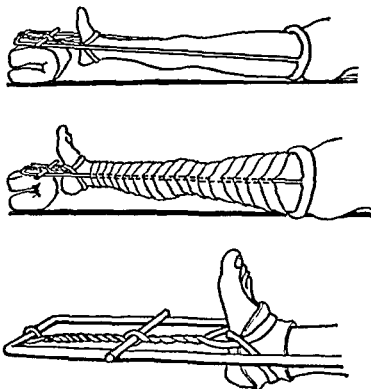


Fig. 382.—Emergency traction. Steady firm traction is manually maintained while the ring of the splint is slipped over the foot and up the thigh to rest against the tuberosity of the isel um. A hitch of a linen bandage is thrown about the ankle over felt or cotton padding and tied taut to the end of the splint. A toe gage depressor or rod of some sort is placed between the two pieces of bandage and twisted for the heel traction (so-called Spanish windlass). The leg is then fastened into the splint by bandage—continuous or a single tied loop above the ankle, one below the knee, one above the knee and one below the hip.

treatment of fracture of the femoral shaft made in a decade.

**Diagnosis.**—The diagnosis is made of course on the basis of the general signs of fracture—soft part pathology, deformity, embarking, shortening, angulation and rotation, false point of motion and in the absence of deformity, on localized pain and tenderness and functional loss. The rotatory deformity is of importance as regards therapy, since it is usually outward in both fragments in the upper due to muscle action and in the lower

**Treatment.**—The emergency immobilization, treatment of shock and handling of compounding, or other soft part injuries are the same as in other fractures. The degree of shock is often a matter of importance since the fracture is frequently the result of severe violence as might be expected from the normal thickness and strength of the bone.

There is no best treatment for fracture of the femoral shaft. There is detailed below a list of the various tried and proved

methods available with the conditions under which each is best used. The methods are listed in the order of their theoretical efficiency based on abstract principles. It is readily seen that under any given set of circumstances a method listed low in the order of theoretical efficiency may be by far



Fig. 333.—Fracture of femoral shaft. Spiral fracture. Note outward rotation of lower fragment and outlines of Thomas splint as used for emergency traction. The ring with small amount of soft parts intervening rests against the ischial tuberosity. The lower fragment was firmly embedded in the vastus externus and the upper half pierced the crureus and entered the rectus. The patient was seen and a Thomas splint applied several hours after injury and after two manual attempts at closed reduction there was overriding. Despite the emergency traction. Had the Thomas splint been applied immediately and the part kept under traction until adequate treatment was available the reduction might have been accomplished without the necessity for operation.

the best one to use. One of the reasons for the deplorable number of disabling femoral shaft fractures is the tendency to use a *method*. The remark, "I use such and such a method for fracture of the femoral shaft," indicates merely complete lack of comprehension of the problem and condemns a

certain number of patients to failure from the outset.

1. Open reduction with rigid internal fixation followed by balanced suspension and active motion in such suspension starting from five to seven days after operation.

This method of attack is on paper ideal. It secures anatomical reduction with a very small amount of real damage to the tissues; rigid fixation of the fragments without immobilization of joints; almost immediate resumption of at least partial function and complete accessibility to the soft parts of all forms of early physical therapy.

In practice to make this attractive picture a true one, one must have—

1. A patient who is an excellent operative risk.

2. A surgeon who has had adequate special training and experience in operative work on recent fractures.

3. Assistants similarly trained, surgeons and nurses.

4. An operating room organization designed to facilitate the rigid detailed technique which is necessary without loss of time and with minimum trauma to the patient.

5. Equipment (instruments, etc.) designed to facilitate the ease of operative reduction and minimum of trauma to the tissues and security of internal fixation.

6. A fracture of such type as regards comminution, line of fracture, etc., that rigid fixation at operation is insured.

7. An organization adequate for insuring that postoperatively the patient's balanced suspension will be properly set up and properly maintained and that active mobilization will be adequately and safely carried out.

This is a most demanding set of circumstances. The answer is of course that there are very few places where the procedure as outlined can be pursued as a method of choice with safety. It is important to realize that the result and the safety of the procedure depend less on factor 2 than on the others listed. A surgeon who fulfills the requirements listed under 2 is often deluded into believing that he is the most essential factor. One cannot emphasize too much the fact that this is a delusion. Unless all of the factors listed are present, the choice of this method is neither safe nor sane. There is here neither time nor space to go into the

question of operative treatment of fractures in detail. But even the little which has been indicated should give the idea that this method is not one that is suitable for use by the average surgeon.

Figures 383 and 384 show a typical spiral of the femoral shaft treated by the above method. This patient was never in plaster, was walking on a caliper splint at six weeks, had a practically full range of motion in the hip, knee and ankle at that time and was back at clerical work in three months and walking without any support and with full

II Traction suspension with a Thomas splint and the Pearson leg piece and skeletal traction and active mobilization.

This method should provide fairly rapid reduction with a minimum of trauma, considerable functional activity of the part during healing, rapid abolition of soft part pathology through elevation, active muscle function within pain limits and early physical therapy.

The indications for its use are—

1. A patient who can be kept in bed for six or eight weeks or longer. This involves



Fig. 384.—Plated fracture of femur. Fracture shown in figure 383 after plating. The anatomical replacement of the fragments is obvious and the rigidity of fixation is such that active mobilization in balanced suspension has been started five days postoperatively. Since the splint is merely being used here as a suspension apparatus there is no necessity for having the ring under the tuberosity of the ischium for counter traction as is the case in figure 383. This form of fixation utilizes a long plate with six screws passing through both cortices of the bone. It is, however, a fixation in only one plane and is not as safe or as logical as the fixation shown in figure 385.

function at four months. He was treated under conditions fulfilling all the requirements listed. For every such case there can be shown at least ten others in which the surgeon considered only his own excellent operative ability. These patients have taken a longer time to recover and have a poorer functional result than if they had been treated by a closed method.

Operative reduction followed by plaster immobilization as a primary procedure of choice gives a good x-ray picture but is more apt to prolong the convalescence than to aid it.

physical, economic and mental/emotional factors.

2. An organization capable of properly applying and maintaining the apparatus and of insuring the practice of active motion by the patient.

3. A patient who can be reasoned, cajoled or bulldozed into practicing active motion as directed.

4. The use of surgical precautions in the insertion of the skeletal traction.

5. The line of fracture which particularly calls for this type of treatment is the oblique and spiral and the comminuted in which

maintenance of reduction is difficult by plaster

The details of the traction suspension are discussed under intertrochanteric fractures and are illustrated in figures 369 375 376 377 and 380 Lateral and anteroposterior displacements can be corrected by appropriate sling and pulley weight pull

An essential point in all traction-suspension is to accomplish reduction in hours—not in days or weeks After reduction is accomplished at least weekly roentgenographic checks should be made for position and healing

tained The advantages of active motion and early physical therapy as indicated under II are lost

The reduction as indicated under II may be followed by a plaster spica as soon as reduction is accomplished The Anderson well leg traction or the Hoke well leg traction may be used in fractures of the femoral shaft The author does not recommend them The other methods described are more satisfactory

The Stader Haynes or Roemer Anderson apparatus may be used They are not as satisfactory in the femur as they are in other

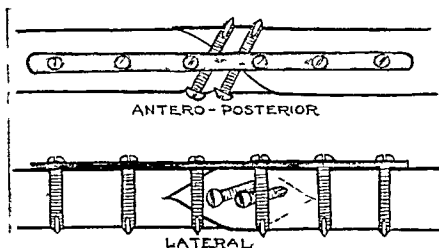


Fig 393—This type of fixation is preferable to that shown in figure 394 The length of the plate is between four and five times the diameter of the bone the screws which fix it pass through both cortices and in addition two screws are inserted oblique from one fragment through the other in a plane relatively at right angles to the plane of the screws fixing the plate This gives fixation in two planes and relieves the plate and the screws fixing it from torsional strain and shearing strain This greatly reduces the possibility that the plate or screws will become loose under the strain of functional activity If there is a loose intermediate fragment it should be fastened to one of the main fragments by means of screws before the plating and the screw cross fixation are done This is the method routinely used on the Fracture Service of the Presbyterian Hospital in New York with very satisfactory results

The line of traction and suspension is indicated by the position of the proximal fragment

The length of time that traction is maintained is gauged by the x-ray film and clinical evidence of union

The removal of traction is followed by the use of a caliper brace for a varying period or the progression from crutches to cane depending on the strength and amount of callus and the weight of the patient

III Reduction by skeletal traction followed by or accompanied by immobilization

The value of reduction within a question of hours with a minimum of violence is re-

gions For the technique of their use the references listed at the end of this section should be consulted

Skin traction with a Thomas splint and the Pearson leg piece is suitable only for those patients with little or no displacement and for whom it is desired merely to maintain position during healing In view of the fact that it does not safely allow active mobilization and in view of the relatively complicated arrangement as compared with the Russell traction it should be displaced in these days in favor of the latter

IV Russell traction (Fig 379) This secures adequate traction allows early phys-

cal therapy, allows great freedom of the patient's movements in bed simplifies the nursing care is simple to apply and requires practically no special apparatus. It is less secure than when a Thomas splint and the Pearson leg piece limit lateral and antero-posterior movements of the fragments. It does not allow safely of any degree of active knee joint motion.

Indications for its use are

- 1 Lack of equipment
- 2 Lack of organization for application and maintenance of it

- 3 Danger in use of skeletal traction (skin infection in patient surgical technique difficulties in the operating room or personnel necessity for treatment in the home)

V Manipulative reduction followed by plaster immobilization

This can be carried out anywhere. It requires no apparatus and no particular organization. After care is limited to checking on the position at weekly or bi-weekly intervals and nursing for skin care and positional change. Little or no hospitalization is required. The reduction can be done under local anesthesia.

The method is in itself disabling because of the relative violence of the manipulations required (often as great as or greater than that of the original fracture) and because of absolute and often prolonged immobilization of the part with inability to carry out an early attack on the soft part pathology by physical therapy. In cases of oblique spiral and comminuted fractures it is less apt to secure good position and less apt to maintain it once it is secured. It is more apt to result in skin and pulmonary complications.

The chief indication for its use is absolute necessity because of inability to use any of the preceding methods.

It is a matter of importance to realize that the choice of the best treatment available under the circumstances should be made when the patient is seen and should be immediately instituted. The rationale of trying the simplest and easiest known method first (unless it is the only one possible) and progressing after each failure to the next more efficient though more difficult method shows not only poor surgical judgment but is evidence of lack of common sense and is

responsible in large measure for poor results. The problem is not that of what is the easiest way in which the condition can be treated but rather what is the most efficient way in which the problem can be handled under the circumstances.

Following union the usual routine of exercise aided by physical therapy and/or occupational therapy is instituted. Weight bearing with brace support or crutches progressing to cane and then full weight bearing is followed in accordance with clinical and x-ray evidence of consolidation of the union for all these methods.

VI Operative reduction as a matter of necessity

It is important to recognize the indications for this as early as possible. Operative treatment following non union is far less effective than early operative intervention.

The indications are

- 1 Interposition of tissue as indicated by failure to secure bony contact (crepitus) during manipulation or the application of traction

- 2 Vascular or nerve lesions at the fracture site warranting emergency intervention

- 3 Extensive compounding particularly from without

- 4 Inability to obtain or to maintain satisfactory position by non-operative means with reasonable celerity. The procedure at operation and the postoperative handling are based on the indications that have already been enumerated.

Prognosis.—The shaft of the femur that is adequately cared for is usually healed in from six to ten weeks. It may require from twelve to fourteen weeks. Weight bearing with brace is usually possible at that time (walking caliper Fig 368).

In general all other factors being equal the convalescence time to full function and walking ability increases with the method of treatment used in the order as listed and varies with the patient's occupation. This gives a leeway of from four months to a year or longer.

The mortality in the average case should depend almost entirely on the question of shock and other concomitant injury except in the aged in whom the factors described under fracture of the neck of the femur become a matter of importance.

## SUPRACONDYLAR FRACTURES

Supracondylar fractures, while not exceedingly common are rather difficult to handle because of the characteristic deformity (Fig 386). The age incidence is fortunately that of the young and middle-aged adult group. The healing time is somewhat slow normally, and this is a factor of importance in the election of a method of treatment.

The diagnosis rests on the presence of the local signs including a characteristic bowing of the thigh above the patella, the bow open forward. There is shortening in accordance with the degree of overriding. Lateral or medial angulation also may exist of

listed under fractures of the femoral shaft with the same indications and subject to the same reservations.

When skeletal traction is used traction in the direction of the femoral shaft must be aided by a lifting sling under the lower fragment and/or the application of the Pearson leg piece just at or just below the fracture (Fig 386).

When plaster immobilization is used the knee and hip must be in sufficient flexion to maintain correction. This requires the type of semi sitting splint described under subtrochanteric fracture.

Well leg traction is not adapted to the treatment of this fracture, and ordinary skin

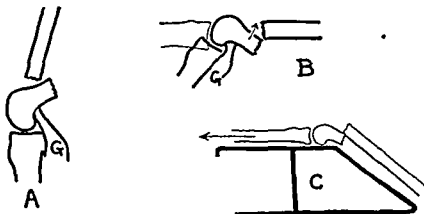


Fig 386—Supracondylar fracture. A Characteristic deformity maintained by gastrocnemius. G. B Effect of flexion of knee in relaxing gastrocnemius. C Further effect of combining some knee flexion with a Thomas splint and Pearson leg piece having the leg piece angled at the site of fracture instead of at the axis of knee joint motion (compare with Fig 377). In the illustration a supporting framework in the nature of an inclined plane similar to the Braum, Blier etc., fracture frames mentioned in the text is shown with the change in incline occurring at the fracture site instead of at the knee joint. It is obvious that with a little more traction the weight of the part will correct the anteroposterior displacement and the flexion of the knee and the angulation of the splint will correct the angular deformity.

course. The lower fragment is usually rolled outward.

It is necessary in reduction regardless of the method used to exert three forces—traction in the line of the femoral shaft, rotation of the lower fragment in the anteroposterior plane in which the lower end goes backward and the upper end forward and a lifting force on the lower fragment as a whole (compare with subtrochanteric fracture) to overcome a gravity effect resulting in posterior displacement. The second of these forces is accomplished by the necessary degree of knee flexion plus a fulcrum (hand suspension or sling) at the level of the fracture (Fig 386).

The choice of treatment runs about as

traction is of little value. The Russell traction is probably not at its best in this type of fracture. The very low supracondylar fracture is not suitable for operative treatment.

**Prognosis**—The healing time in this lesion in adults is usually from eight to twelve weeks but it may run to fourteen or sixteen. There is a corresponding prolongation of the convalescence as compared with that in cases of fractures of the main portion of the femoral shaft. The remarks made on the mortality in fractures of the femoral shaft apply equally here.

## CONDYLAR FRACTURES

Condylar fractures are rare and of two types. A single condyle or both condyles are



split off usually as a result of severe violence of a more or less direct type with accompanying hemarthrosis of the knee joint.

Pin traction through the tibial condyle is indicated as the primary procedure of choice in the position calculated to secure reduction dependent on deformity.

If the displacement is exceedingly great or if in from twenty four to forty eight hours it is obvious that pin traction is not effective then operative reduction and fixation are indicated. The results of operative treatment may be excellent roentgenographically but the lacerations of the soft parts within the joint frequently lead to prolonged difficulty in regaining mobility. The same difficulty is encountered in other methods of treatment.

The second type almost invariably involving the external side is that in which the femoral condyle is impacted upward by forcible abduction of the leg on the thigh as when the patient is struck on the outer side of the leg by an automobile bumper or fender while the foot is fixed (Fig. 387). This gives local symptoms over the outer aspect of the lower femur usually hemarthrosis and a varying degree of possible abduction of the leg on the thigh in full extension a possibility not present in the normal knee joint to any appreciable degree. The amount of abduction possible depends entirely on the degree of impaction of the condyle viz elevation of the external condylar surface. If this abduction is possible to more than 10 or 15 degrees the fragment either should be malleted down to its normal level or if this is impossible should be operatively replaced and fastened. When the abduction is not sufficient to warrant correction or following correction as indicated the best treatment is by suspension with mild (3 to 5 pounds) traction on the leg and active mobilization as indicated heretofore—preferably with a Thomas splint and the Pearson leg piece.

Union is inclined to be slow and the healing callus must be protected for some time against full weight bearing either by brace or crutch. The time required for union is usually six to eight weeks and it is usually from twelve to sixteen weeks before full weight bearing can be allowed.

If it has been unnecessary to correct the

displacement a brace or crutch can be used after two weeks and full weight bearing can be attained in six or eight weeks.

Aspiration of the hemarthrosis is indicated when the joint is not operatively opened and repeated if necessary.



Fig. 387.—Contraction of fracture of external condyle. The dotted outline represents the normal. The abnormal abduction which can be effected is obvious.

The usual attention is paid to active motion and the pathology of the soft parts throughout the course.

#### FRACTURES OF THE FEMUR IN CHILDREN

The problem presented in children is different in many respects from that in adults. The fracture of the neck of the femur is represented in this group by separation of the upper femoral epiphysis. Supracondylar fracture occurs in older children but in younger ones it is represented by separation of the lower femoral epiphysis. Fractures of the shaft are common but do not have the disabling character of those in adults owing to compensatory powers present in childhood which make the problems of prolonged immobilization and of deformity matters of much less consideration.

**Upper Femoral Epiphysis.**—One must distinguish between three separate conditions in this region each of which may present a history of injury with pain and spasm about the hip joint and with shortening, adduction and eversion deformity. There are true traumatic separations of the upper femoral epiphysis, separation associated with the epiphysis of the Trichin syndrome (obesity and backwardness of primary and

secondary sex characteristics) in which very mild trauma is the rule and Legg Perthes' disease in which no real displacement exists.

The true traumatic separation requires relatively severe violence for its production. The other two may present such a history but usually present themselves after mild trauma and careful questioning of the child or its parents will elicit a history of previous trouble with the hip of a mild nature (slight limp, disinclination at times to engage in violent play with other children and complaints of intermittent mild pain).

The roentgenograms of the first and second conditions may be identical except that in the latter there is evidence of irregularity and abnormality in the epiphysis on the

diagnosis is almost certain and the roentgenogram gives definite evidence.

**Treatment**—Whether the case belongs in the first or the second group the reduction is best accomplished by the Whitman procedure and followed by the Whitman spica (see Fracture of the Femoral Neck). There is no need in these cases for outward traction on the thigh.

If the child is normal immobilization in the spica for from eight to twelve weeks is indicated followed by gradual resumption of weight bearing. If the child shows a Frohlich syndrome the immobilization period should be doubled and once weight bearing has started careful and frequent roentgenographic checks for recurrence

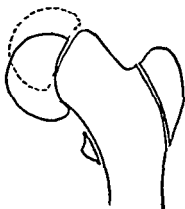


Fig 388



Fig 389

Fig 388—Separation of upper femoral epiphysis. It can be readily seen that abduction is essential to reduction of the displacement. Dotted line represents very mild degree of displacement and need by slight tilt of head and slight bending of upper end of the epiphyseal line.

Fig 389—Legg Perthes' disease. It can be seen that the head lies in its normal position; it is flattened and the ossification center is dense and is flattened and fragmented.

normal side (Fig 388). The child's physical characteristics of course establish the diagnosis. In fact in any child of the Frohlich type who complains of pain in the hip with or without trauma a slipped epiphysis should be suspected.

The picture in Legg Perthes' disease is quite different and differentiates the condition from the epiphyseal separations (Fig 389).

The diagnosis of slipped epiphysis is based on the history of trauma, the local signs of pain and tenderness with limitation of motion and spasm in the hip joint and if enough deformity exists corresponding degrees of shortening, eversion and adduction. If the patient is of the Frohlich type the

should be made. If there is a recurrence operative reduction and fixation (probably best by the Smith-Petersen nail) is indicated.

In the true traumatic cases the prognosis is excellent in the majority of cases. A small percentage probably around 5 per cent show disturbances of growth in the head with deformation and traumatic arthritis subsequently. This is worthy of note since not only must the child be followed with this in mind but in every case it is the part of wisdom to call the parents' attention to the fact that it may occur. There is no way of telling in which case it will occur since the amount of separation seems to be no criterion. If it does occur and the parents

have not been warned of the possibility they frequently consider that the treatment was responsible for the subsequent difficulties. In the Frohlich cases the prognosis is always dubious since coexisting disease of the epiphysis is present. It is probable however if the condition is recognized early if accurate reduction is accomplished and if prolonged immobilization is practiced that the outlook is not too poor. In view of the prolonged immobilization needed and the possibility of recurrence primary closed or open reduction plus the insertion of a Smith Petersen nail in adequate hands is coming to be looked on with increasing favor.

**Separation of the Lower Femoral Epiphysis**—This is characterized by one of two displacements that characteristic of the

displaced backward or downward and backward pressure if it is displaced forward (Fig 390). It is frequently difficult of accomplishment. Prolonged and steady traction (five minutes at least better ten) under anesthesia preceding the actual manipulation is probably the greatest aid to success.

The immobilization is with the hip and knee in flexion in the semi sitting spica described under subtrochanteric and supracondylar fractures. It should be maintained for six or eight weeks.

If manual reduction is not possible in view of the fact that operative reduction is rather to be avoided Russell traction may be used for forty eight or seventy two hours and may be successful with the possibility

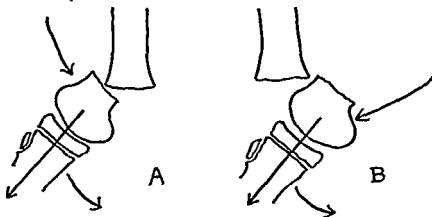


Fig 390—The deformities in lower femoral epiphyseal separation. A Anterior displacement of lower epiphysis. B posterior displacement (as in supracondylar fracture) of lower epiphysis. The direction of the reduction forces described in the text are illustrated by arrows and their effect is obvious.

supracondylar fracture or that in which the metaphysis goes forward instead of backward (Fig 390). In the writer's experience the former has been more common but in the available statistics the latter would seem to be more frequent.

At any rate the indication is for closed reduction if it can possibly be done. This is true of any epiphyseal displacement in the absence of epiphyseal disease since operation probably increases the chances of subsequent growth disturbances.

Manual reduction is preferable and consists in hyperextension of the lower fragment with the knee flexed traction in the direction of hyperextension using the flexed leg as a lever and direct downward and forward pressure on the lower fragment if it is

that gentle manipulation under anesthesia is the patient lies in traction may be needed in addition. If reduction is secured the traction is removed and the spica applied.

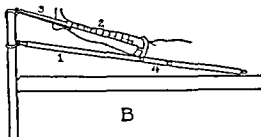
The prognosis is excellent except in those cases in which subsequent growth disturbance occurs. This is a most serious complication since it leads depending on the youth of the patient to anywhere from 1 or 2 to 5 or 6 inches of shortening as growth on the normal side progresses. Sometimes only half the epiphysis—inner or outer—shows any disturbance. In this event an increasing deformity develops in the knee leading to varying degrees of unilateral knock knee or bow leg. Femur lengthenings, destruction of the epiphysis on the sound side or of the sound portion on the injured side and vari-

ous osteotomies may be called for and the decision as to what to do and when to do it may be extremely difficult. It is therefore most important that the remarks made under discussion of the upper epiphysis as to warning parents at the outset of the possibilities and as to keeping the patient under observation after treatment be kept in mind.

**Fractures of the Shaft**—In fractures of the shaft of the femur in children one must seek restoration of the normal axis in both planes, correction of rotation, normal length and end to end apposition. But if there persists up to 1 inch of shortening or angula-

or to operative approach provided the deformities are no greater than those previously cited. Operative approach and skeletal traction in children require considerable justification. The former should be used only in the event of compounding or of interposition of tissue preventing closed reduction. The latter only if in the presence of comminution or extreme obliquity of the fracture line (particularly if compounding co-exists) it seems impossible to keep the residual temporary deformity within the limits previously prescribed for conservative measures or if for any reason the use of the more conservative measures to be detailed is interdicted. When skeletal traction is used, tongs should never be resorted to. Wire traction as described under fracture of the shaft in adults is indicated.

In the newborn fractures of the femoral shaft are best treated by the use of well



**Fig. 391**—A Bryant traction. It will be noted that the buttocks swing just clear of the bed. The legs must be spread enough to allow easy nursing. The adhesive traction strap is covered by a woven elastic bandage. This is of great value in minimizing the chances that the adhesive will slip. This type of traction maintains position in the younger children remarkably well despite their twisting and turning. B Le Mesurier traction. 1 Represents a Brafford frame fastened at an angle to the foot of the bed on which the patient lies. The inclination makes his body weight act as a counter traction force. There is a flap in the canvas at 4 for nursing purposes. The thigh and leg rest suspended in a Thomas splint. Adhesive traction straps, 3 covered by a woven elastic bandage to minimize slipping. 2 are fastened to the end of the Thomas splint, and the Thomas splint in turn is tied to the foot rail of the bed. Traction is furnished by the pull of the patient's body weight against the adhesive fixation to the fixed Thomas splint.

tion of 5 to 10 degrees or 10 to 15 degrees of rotation despite the best of efforts in children up to eleven or twelve years of age there is not the occasion for worry that such a situation would engender in the adult. In the course of subsequent growth such deformities will be almost invariably corrected and there will be no sequelae. This does not mean however that one should not attempt to secure anatomical replacement. It merely means that if conservative methods fail to secure anatomical replacement there is no necessity—actually no excuse—for resorting to repeated re-reductions

padded light basswood corbion splints. They may heal with considerable deformity but without exception they heal and correct the deformity by growth quite rapidly. The attempt to secure accurate reduction and immobilization is a gesture that does more harm than good. The parents should be given to understand the rationale of what may seem to be inadequate treatment otherwise any temporary deformity may cause considerable alarm.

In children up to five years of age the preferable form of treatment is Bryant suspension (Fig. 391). This traction is main-

trained until roentgenographic and clinical evidence of healing have been obtained. No further treatment is indicated. It almost invariably leaves some residual deformity temporarily but anatomical normality as the result of growth adjustments invariably occurs after one to three years. Plaster immobilization in children is unsatisfactory. The plaster soils and softens from excreta frequently and thoroughly requires frequent change and is apt to irritate the skin badly. The contraindication to Bryant traction is an inability to keep the child in a hospital or to provide adequate supervision of the traction straps at home.

For older children manual reduction followed by plaster spica immobilization or the use of traction suspension of the skin type, either that described under intertrochanteric fracture in the adult or the type used by LeMesurier, is indicated (Fig. 391). The latter is best reserved for long oblique and spiral fractures and for comminutions and compoundings which can be handled without the use of skeletal traction.

When plaster immobilization is used in oblique and spiral fractures, traction straps of adhesive are attached to the leg following reduction, the plaster spica is applied leaving the foot free, and the traction straps are brought up around the edge of the plaster and incorporated in it.

It is of note that position must be secured early in these cases, as union is appreciably more rapid than in adults. In children over twelve or thirteen years old the methods used are those used for adults but manual reduction and plaster and skin traction suspension are the most desirable methods.

**Prognosis.**—The immobilized joints practically never present any difficulty, and function usually returns under no other treatment than active exercise. Moderate deformity, as indicated is almost invariably taken care of by growth. Union in small children is usually complete in three or four weeks. In the older group five or six weeks at the latest sees solid union and weight bearing at eight or ten weeks is a conservative estimate.

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## FRACTURES OF THE PATELLA AND OTHER SESAMOIDS

Sesamoid bones are the result of the detachment of ossification centers and are more or less regularly embedded in tendinous structures overlying certain joints. These appear to be more or less incidental functionally and do not interfere with the tendon action. As a matter of fact, they may be an asset to more accurate motion and may help to increase the padding in certain locations, such as in the plantar surface of the metatarsophalangeal joint of the first toe and the metacarpophalangeal joint of the thumb. There are other minor sesamoids that are doubtless developmental or evolutionary remains and are of no functional importance. The patella represents by far the largest sesamoid in the body and is of great

importance to the perfect function of the knee joint. Injuries of this bone are not uncommon and warrant careful treatment. All the other sesamoids are better protected, and injury comes to them usually secondary to more severe trauma to the surrounding parts. Excision of such injured minor sesamoids can be carried out without interfering with the ultimate function of the neighboring structures. Delayed or non-union causing prolonged disability may make it necessary to resort to this radical form of treatment.

**Anatomy of the Patella.**—This large sesamoid is rarely absent. It is spoken of as the "kneecap" and the "kneecap," rarely as the "kneepad." In the adult it varies somewhat in size and shape but is roughly the shape of a broad, thick shield and is about 6 cm long, 5 cm. wide and 2.5 cm. thick. It is slightly convex. The under surface is covered with cartilage and articulates with the condyles of the femur when the knee is flexed. The edges are slightly thinner than the center. The edges and anterior surfaces are firmly attached within the tendinous portions of the quadriceps femoris anteriorly, the vastus internus internally and the vastus externus on the outer side. The tendinous extensions of these various structures unite around the patella, save on its articulating surface posteriorly, and continue on the inferior border to form the strong fascial structure called the "prepatellar tendon," which is attached to the tibial tubercle. Thus, there is a bony structure lying within the great extensor tendon of the knee joint which is of importance to the perfect functioning of this complicated joint. It can be eliminated when necessary because of disease or severe trauma, and the knee will be reasonably serviceable; but careful repair of this sesamoid should practically always be attempted and will usually result in a successful outcome.

**Congenital anomalies of the patella** are not unusual and are often mistaken for fractures. The most common anomaly is represented by a detached fragment of the upper outer quadrant. It was present in 3 per cent of a series of 63 cases of patellar injury reported by Adams and Leonard.<sup>1</sup> The condition is usually bilateral, and a roentgenogram of the opposite knee will help in the

no separation of fragments, the knee should be splinted and elevated until all the excess fluid in the joint has been absorbed (two weeks). Aspiration under careful aseptic conditions may be performed to advantage after the third or fourth day and repeated if necessary. The leg should then be encased

fragments. operative treatment should be instituted. Some surgeons prefer to operate as early as possible, but the majority prefer to wait until hemorrhage has subsided and the joint effusion has been partially absorbed and then operate. The average delay entailed is five days, during which time the joint is

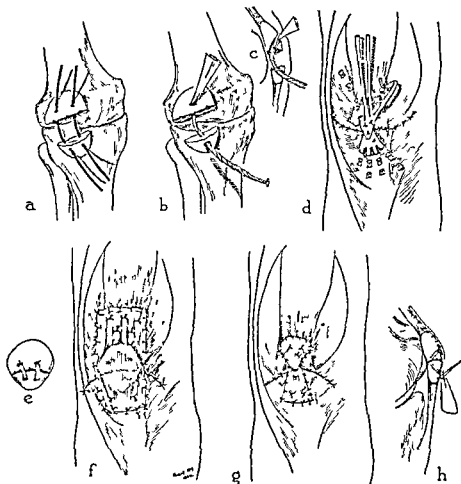


Fig. 392—*a* Small drill holes through which wire or kangaroo tendon or small strips of fascia can be passed *b* massive fascial repair. The drill holes should be 5 or 6 mm in diameter and the fascia lata should be at least 1 inch wide *c* Massive fascial repair. Drill holes through fragments. Note the lack of penetration of the joint surface of the patella with the drill holes *d* method of using massive fascial graft through the drilled fragments fanning out the ends to be planted into the tendinous structures above and below *e* another method of fascial repair. Patella has been drilled. fragments fixed with fascia or kangaroo tendon *f* capsule repaired large plaque of fascia lata to reinforce the tendinous structures *g* repair of patella by single massive fascial graft. The drill hole is larger and the ends of the fascial graft are not split. The upper end of the graft is passed through a hole in the lower end *h* lateral view of procedure shown in *g*

in well padded plaster of paris from the ankle to the groin with the knee in extreme extension. Weight bearing with crutches may be allowed between the third and sixth week, then a cane may be used. The leg should be supported with the plaster of paris case until after the eighth week.

In cases in which there is separation of

splinted and the leg elevated. The capsule may be sutured with cotton silk or fine steel wire and nothing done to the bone itself. When this method is used delayed motion and long splinting may result in considerable loss of function and refracture may take place. Some surgeons prefer to drill the fragments and hold them in apposition with

wire, but the majority of surgeons prefer the use of fascia lata in the repair. The fragments may be drilled and held together with a strong piece of fascia or a large plaque of fascia may be sutured to the quadriceps above and the prepatellar tendon below after the fragments have been approximated and the capsule has been sutured.<sup>3</sup> The capsule itself may be sutured with fascia. A portion of the quadriceps tendon may be detached passed through drill holes and sutured on itself.<sup>4</sup> Whatever method of repair is chosen the most important detail is the suturing of the rent in the lateral expansions of the capsule since the object is to restore continuity in the extensor tendon of the knee joint. The bone itself is helpful but is incidental. Brooke<sup>5</sup> has advocated excising the patellar fragments and discarding them. We believe that this method is most useful in a badly comminuted compound fracture. The tendinous structures should be carefully repaired. The advantages of wire and fascia fixation are principally that they permit early motion and restoration of function. Disability is thereby greatly shortened.

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## FRACTURES OF THE TIBIA AND FIBULA (SHAFTS AND UPPER ENDS)

**Anatomical Considerations.**—The two tibial spines (medial and lateral) the tuberculum intercondylareum mediale and the tuberculum intercondylareum laterale should always be kept in mind while studying an injury about the knee joint since fracture of one or both may result from a severe twist or partial dislocation.

The tibial tubercle which affords the attachment of the ligamentum patellae arises from its own bony nucleus which in early life unites with the upper

epiphysis of the tibia. It is particularly exposed to trauma such as direct blows and to the strains resulting from violent contraction of the quadriceps extensor muscle.

The upper end of the tibia sometimes called the tibial plateau constituting the weight bearing surface with which the lower end of the femur articulates is frequently fractured. The external tibial condyle or the internal tibial condyle may be split off and displaced laterally or may be driven downward. Extensive comminuted fractures of the upper end of the tibia may also occur without injury to the bones otherwise.

The shaft of the tibia is subject to all the varieties of fracture. It is rare however to find a fracture of the shaft of the tibia without a fracture of the fibula and when this does occur it is usually the result of direct violence. *vice versa* the shaft of the fibula is seldom fractured without an accompanying fracture of the tibia and when the fibular shaft alone is fractured it is the result of direct violence. The upper end of the fibula articulates with the tibia and fractures of this portion of the fibula alone are usually the result of direct violence.

Both bones of the leg are fractured with the greatest frequency the fractures occurring at any place in the shafts of the bones. The most common site of fracture of the shaft of the tibia is in the middle third and the fracture of the fibula is usually at a higher level. A fracture of the tibia with overriding of the fragments always means an injury to the fibula, an injury which should be located. The fractures are too rarely transverse the most common being the oblique fracture. Spiral fractures and comminuted fractures occur with great frequency.

**Etiology.**—The tibial spines are injured when as a result of trauma one of the femoral condyles strikes the tibial spines and knocks one or both from the attachment.

The tibial tubercle which is a prolongation of the proximal epiphysis downward on the anterior surface of the tibia is always exposed to direct trauma. The ligamentum patellae also inserts into the tibial tubercle and as a result of violent contractions of the quadriceps muscle the tubercle may be partially or completely loosened from the underlying shaft of the tibia.

The upper end of the tibia is frequently injured when a person is struck by an auto mobile bumper which is at about the level of the knee joint. A fracture of one of the condyles of the tibia may be produced by this trauma. Tackling in football and falling downstairs may produce a similar injury. A fall from a height as from a railway box car may produce a severe comminuted fracture of the upper end of the tibia.

The shaft of the tibia may be fractured as the result of turning quickly with the foot



fixed. Starting with this simple etiologic factor it is readily understood that there are innumerable forms of direct and indirect violence which may produce a fracture of the shaft of the tibia. The shaft of the fibula is usually fractured at the same time and at a higher level.

A fracture of the tibial shaft or of the fibular shaft without fracture of the other bone is always the result of direct violence such as the kick of a horse or similar direct force.

**Pathology.**—Fracture of the tibial spine is often incomplete but when it is complete the spine becomes a foreign body in the knee joint.

The tibial tubercle fracture is usually incomplete and the separation and elevation of the tubercle result in an increased prominence of this region.

Fractures of the upper end of the tibia involving the knee joint always produce hemorrhage into the knee joint. Secondary adhesions may develop in and about the joint and thickening of the connective tissue elements surrounding the joint also results. The articular surface of the tibia is widened and the ligaments surrounding the joint are forced into abnormal positions. Disturbances of the attachments of the crucial ligaments may be produced. The semilunar cartilages may be injured either in the cartilaginous portions or in the ligamentous attachments. Fragments of bone may become detached and may become foreign bodies in the knee joint. The formation of excess callus extending into the knee joint is unusual and is thought to be prevented by the action of the synovial fluid.

Fractures of the shafts of the tibia and fibula produce the same pathologic changes as fractures of the other long bones. The minimal changes are negligible and the maximal changes may produce very great permanent disability. Blood escapes into the soft tissues surrounding the donor and follows the arterial sheath producing ecchymosis in the most dependent areas. The sharp ends of the bone may lacerate the surrounding periosteum, muscles, tendons, blood vessels, nerves, lymphatic vessels, fascia and even skin. If the skin is lacerated the fracture becomes compound and in fact may occur.

The damage produced in the soft tissues by the sharp ends of the fractured bone and the escape of blood into the soft tissues both from the ends of the broken bone and from torn blood vessels cause interference with the return circulation of the extremity. The circulatory stasis produces swelling which is chiefly during the first few hours. The inflammatory reaction of the tissues to injury begins at once to stimulate the formation of permanent new tissue in the same manner as elsewhere. The fluid which has accumulated in and between the different soft part structures is accompanied by the various cellular elements which increase organize and produce permanent inflammatory changes and new tissue which is not removable. These early pathologic processes should be kept in mind particularly in fractures of the shafts of the tibia and fibula.

When the tissue fluid collects in excessive amounts in the leg where there is only limited room for expansion one frequently sees the formation of large blebs of fluid covered by superficial layers of skin.

**Symptomatology.**—Fracture of the tibial spines never occurs as an uncomplicated injury. The symptoms are pain and swelling in and about the knee joint. If the knee joint is aspirated blood stained liquid is obtained.

Fracture of the tibial tubercle occurs most often as an uncomplicated injury to the tibial tubercle with pain and swelling at this point. The symptoms are increased by flexion of the knee thus increasing the tension of the patellar tendon.

Fractures of the upper end of the tibia always produce swelling of the knee joint. Movements of the knee joint are painful and the knee is weak and unstable, the instability varying with the extent of the fracture.

When only the shaft of the fibula is fractured tenderness and swelling and later ecchymosis develop about the site of the fracture. Weight bearing may be possible. When only the tibial shaft is fractured there is tenderness and swelling about the site of fracture but if the fracture is complete weight bearing cannot be tolerated. When the shafts of both bones of the leg are fractured there is pain, tenderness and swelling at the site of fracture and abnormal mobility.

**Diagnosis.**—When a bone is fractured or when a fracture is suspected the diagnosis should be made by means of properly taken x-ray pictures. Anteroposterior and lateral views should be taken on films large enough so that the injured area may be completely studied but not so large as to cause distortion of the portions at each end of the film. If a complete diagnosis of the fractured bone is not thus obtained further roentgenograms should be taken. It is more important for the student to familiarize himself with the normal physical findings and with the conditions due to trauma which are not fractures and thus be able to rule out a fracture than it is to know and use the Twentieth Century methods of diagnosing fractures. A review of the foregoing paragraphs regarding the pathology should suffice to prevent anyone from an effort to obtain the signs of abnormal mobility or of crepitus. The obtaining of more evidence of abnormal mobility than that indicated by the slightest

diagnostic movement or the moving of the broken fragments sufficiently to cause crepitus is no longer justifiable. Pain and tenderness may be searched for and with a proper history may indicate the necessity of an x ray study. Technicosis following an injury which may have caused a fracture places the burden of proof on the person who says there is no fracture therefore an x ray examination is indicated.

A proper and complete diagnosis is highly economical in industry because if a fracture exists the earliest possible appropriate treatment will produce earlier and more complete recovery and therefore an economic saving to both patient and employer. On the other hand if it is possible that a fracture has been sustained but the x ray plate shows that none is present then the patient may return to work with a minimal loss of time again to the advantage of all concerned. Similarly in the aged the young and the unemployed when a fracture cannot be ruled out a roentgenogram should be obtained because of the resulting economic advantage to the patient.

Up to the time when the fracture is sufficiently healed to prevent changes in the relation of the fragments from occurring it is necessary to repeat the x ray studies and re-diagnose the condition of the fracture whenever changes may have occurred accidentally or as the result of treatment.

**Prognosis**—When a tibial spine is completely fractured there is little to prevent it from becoming a loose body in the knee joint. Incomplete fracture of the tibial spine will heal satisfactorily if recognized early and if the part is placed at rest.

Fracture of the tibial tubercle heals kindly with no permanent disability when appropriately treated but there will be some increased prominence of the tibial tubercle resulting from this injury.

Fracture of the tibial plateau involving the knee joint is always serious and always produces permanent disability unless promptly and adequately treated. When the fracture is of slight extent and situated so that weight bearing will not increase the deformity it may be that a fracture will heal with the best result if it is not recognized because of the ensuing early use and the lack of fixation. In all other conditions however

this injury produces limitation of motion of the knee joint and deformity of the joint surface and if left untreated results in instability and discomfort. In the more serious injuries with simpler methods of treatment the loss of time in the case of active workers is apt to be considerably over one year whereas with the more active treatment the time loss may be considerably less than a year and the permanent disability negligible.

Fractures of the shaft of the fibula heal without permanent disability in a few weeks. Fractures of the shaft of the tibia alone may result in slight shortening but otherwise heal kindly with the simpler methods of treatment and the x ray film will show good healing in approximately three or four months.

Fractures of both bones of the leg may have a very serious prognosis. Adequate first aid treatment will prevent further damage to the soft parts. Injury to the soft parts is responsible for most of the resulting disability after the bone has healed. Adequate treatment will prevent shortening and deformity. Active workers will need from five to seven months before they may return to duty after this type of injury. When the lower third of the tibia is involved delayed union may result. Non union requiring bone grafting however occurs but rarely.

**Treatment**—Treatment of fractures of the tibia and fibula should be started immediately. Splint them where they lie; it is a valuable slogan. The first obligation is to apply proper first aid treatment to prevent any further damage. Since the healing process starts at once it is important to apply first aid treatment which will facilitate the progress of the efforts of nature. The Keller Blake hinged half ring splint should be applied before the patient is moved and the patient should then be transported promptly to the x ray room and the diagnosis completed followed at once by the institution of the form of treatment which is required. If a first aid splint which permits the application of traction is not at hand then flat board splints may be used and should extend well up on the thigh and down below the foot in order to be at all efficient. However any splint which does not permit traction should be considered a makeshift.

Complete fracture of a tibial spine is very

apt to result in the presence of a foreign body in the knee joint which may require removal by arthrotomy. When the x-ray picture shows the fracture to be incomplete a simple posterior splint applied for from four to six weeks will be sufficient. This splint is then removed and only guarded use is made until all symptoms have subsided.

A fracture of the *tibial tubercle* usually is not accompanied by wide separation of the fragments. A felt pad may be placed over the tubercle and held in place by firm adhesive plaster strapping. The adhesive plaster should be crisscrossed over the thigh above the patella and down onto the leg in order to relieve the tension of the quadriceps muscle. A posterior splint should be applied for approximately two months. X-ray studies should be made so as to follow the progress of healing. When wide separation of the fragments occurs an open operation is indicated. The fragment is fastened by one or two bone pegs through the tubercle into the tibia. A hole may be drilled through the tibia and a non absorbable suture passed through the hole and fastened in the patellar tendon just above the tibial tubercle. The treatment is thereafter the same as in the non-operative cases.

A fracture of the *tibial plateau* is always accompanied by hemorrhage into the knee joint and the presence of this blood may tend to keep the fragments displaced. Aspiration of the hemarthrosis is frequently indicated. Application of extension by means of weights and pulleys either on a fracture table or in bed will help to reduce the fracture when it is not too severe. The fragments may be brought into position by extension with weights and then approximated with a carpenter's clamp. The amount of weight required may be 25 pounds or more. Felt padding is then placed on either side of the upper end of the tibia and molded plaster splinting is applied snugly extending from the toes well up on the thigh. There is danger of the development of pressure sores if plaster is applied too tightly and of redisplacement of the fragments if the splinting is not tight enough. Follow up x-rays must be taken at regular intervals during the first two weeks of treatment and if displacement of the fragments occurs some other method

of treatment should be considered. Approximately six weeks may be required before union is obtained. The apparatus is then removed and treatment directed toward the restoration of the normal function of the knee joint.

Limitation of the motion of the knee is apt to result following this type of fracture. Pain on motion at the knee joint may also persist. The ideal treatment therefore consists of early motion and late weight bearing.

When the fracture of the head of the tibia is extremely comminuted excellent results have been obtained by placing the patient in bed with the extremity suspended from an overhead wooden frame in a Thomas splint with a Pearson attachment which permits motion at the knee joint. A Kirschner wire is passed through the os cruris and an attached extension cord passes over a pulley fastened to the distal end of the Pearson attachment with a 6 pound weight. A second pulley is fastened to the same place on the splint and another cord from the skeletal traction apparatus passes through this pulley and upward to a pulley on the overhead frame here an 11 pound weight is attached. The additional weight upward counterbalances the first weight plus the weight of the leg. Roentgenograms are taken at the end of twenty four hours and the weights are increased or decreased according to the condition revealed. Motion is started at once and continued throughout the treatment. The fragments of the tibial plateau are forced into improved position by the femoral condyles during the passive movements of the knee joint. Roentgenograms should be made at intervals during the first ten days and a satisfactory weight bearing surface should be demonstrated without too much increase in the width of the tibial plateau. There is surprisingly little pain in the knee joint movement when traction is applied in this balanced manner. The patient may be removed from the apparatus as soon as sufficient healing is demonstrated roentgenographically usually after about six weeks. Weight bearing is not permitted for about three months.

Operative treatment may be used to great advantage combined with skeletal traction and early motion as described in the preceding paragraph whenever there is a dis-

able fragment of the tibial condyle on each side of the fractured upper end of the tibia and when satisfactory reduction and fixation are not obtained by other methods A short curved incision is made just anterior to the head of the fibula beginning at the level of the upper end of the tibia and ending about  $1\frac{1}{2}$  inches distally The flap is turned forward and the tibial cortex exposed A drill is passed through the fragments parallel to the knee joint and on the medial side a similar incision is made to permit the drill to come through A  $\frac{3}{8}$  inch bolt is then passed through the drill hole and tightened as much as desired under x ray observation

joint and the stability of the knee joint is but rarely impaired

When the shaft of the fibula alone is fractured it is so well splinted by the tibia that the treatment required is similar to that of an injury of the soft parts Fracture of the tibial shaft without accompanying fracture of the fibula also has the advantage of a natural splint one which prevents over riding The injury to the soft parts may be slight and fixation of the extremity in molded plaster splints including the lower two thirds of the thigh and the foot may suffice The x ray plate may show good formation of callus in six weeks, and all appa

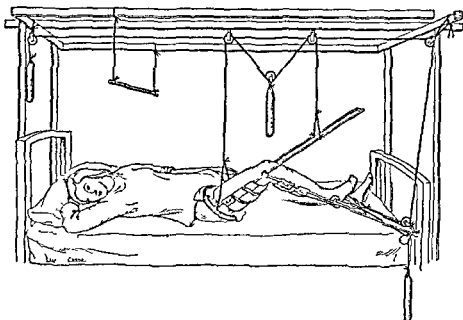


Fig 293—Apparatus for treatment of fracture of the tibia Traction is applied to a Kirschner wire through the condyles and so arranged as to permit flexion and extension of the knee

before closure of the wounds It is not necessary to remove the bolt

It is seldom necessary to open the knee joint to remove loose bodies or injured semilunar cartilages The exploration of the knee joint may increase the surgical risk unnecessarily in many instances and the loose bodies or damaged cartilages can be removed later if they are producing unfavorable symptoms The bolt with washers fastened at both ends has an advantage over screws and nails because of the elimination of the danger of loosening during motion of the knee joint Early motion during treatment gives a less painful and more movable knee

ratus may be discarded in approximately three months

Fractures of the shafts of both bones of the leg may be transverse oblique spiral or comminuted When the fracture of the tibia is found on x ray examination to be transverse and displaced the patient should be given ether anesthesia or a spinal anesthetic and the ends of the bone placed in apposition Molded plaster splints are then applied from the toes to the upper half of the thigh When the ends of the tibia are in apposition the fibular fracture requires little if any attention

Occasionally the fracture of the fibula may

be transverse and the tibial fracture of an other variety. In selected cases of this type a small incision is made over the site of the fibular fracture and the ends are placed in accurate apposition. Moulded plaster is then

tempted to reduce oblique fractures under anesthesia followed by the application of plaster cause added injury to soft parts and result in over riding and angulation of the fractured bones. The leg should be elevated



Fig 394

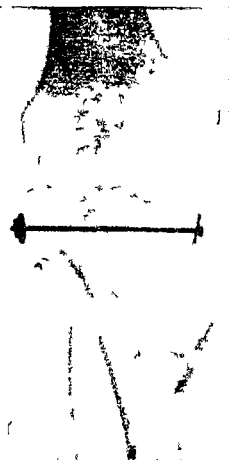


Fig 395

Fig 394—Markedly comminuted fracture of the proximal third of the right tibia involving the knee joint with marked distortion of the tibial condyles in a locomotive fireman aged forty five who fell from an engine cab onto a rail. He was first placed in suspension and skeletal traction. After four days of traction the upper end of the tibia was compressed with a carpenter's clamp but after removal x rays showed no improvement. The upper end of the tibia was then bolted and the knee joint was exercised frequently. In suspension and skeletal traction. Three and one half months after injury he left the hospital bearing removable molded plaster splints and crutches. The knee was exercised twice daily and would flex to a right angle. Ten months after injury he returned to work as a fireman. Eighteen months after injury he reported having been skating for four hours continuously. The knee joint extended to 110 degrees and flexed to 47 degrees and there was no sign of weakness or instability of the knee joint.

Fig 395—Anteroposterior roentgenogram showing the Kirschner bolt and washers in the upper end of the tibia.

applied and the subsequent treatment is the same as in fracture of the tibia alone.

Fractures of the shafts of both bones of the leg are usually not transverse and should be placed in suspension or at least in elevation and in skeletal traction. Reduction by traction is the only method to be used. At

to assist the part to recover from the disturbance of circulation. With elevation gravity assists the return flow of blood and lymph and diminishes the pathologic changes which result from stasis. The improved circulation hastens the healing process. Skeletal traction by means of a Kirschner wire

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## TRACTURES OF THE TIBIA AND FIBULA INVOLVING THE ANKLE

Classification —Fractures of the tibia and fibula involving the ankle comprise

- 1 Abduction fractures
- 2 Adduction fractures
- 3 External rotation fractures
- 4 Extension fractures
- 5 Flexion fractures
- 6 Fracture of the lower end of the tibia (compression)
- 7 Atypical fractures

These fractures are in the main caused by indirect violence and are best studied and understood by grouping them according to the direction or application of the fracturing force (Ashhurst)

Fracture of the ankle is sustained when the motion at the ankle joint is carried beyond its normal range External rotation fractures are the most frequent (10 per cent) and with abduction and adduction fractures comprise 95 per cent of all ankle fractures Internal rotation seldom if ever produces a fracture because there is considerable normal excursion of the ankle in this direction a sprain or simple laceration of ligaments rather than a fracture results when the ankle is forcibly rotated internally Furthermore though ankle fractures for the purposes of description and study may be divided arbitrarily into well recognized groups in actual experience some fractures may be observed which result from a combination of several fracturing forces i e not simply from abduction alone but from abduction external rotation and extension (plantar flexion) combined

Anatomy —It is important to recognize that the ankle is a mortice joint in which the astragalus fits into the mortice formed by the lower ends of the tibia and fibula The important and essential structures from a fracture standpoint that maintain this mortice are the internal and external malleoli the posterior articulating surface of the lower end of the tibia (pos

through the os calcis affords the most satisfactory method of reduction The amount of extension weight required for the average patient is 15 pounds The position of the fragments and the amount of extension are obtained by careful measurements by palpation of the tibial crest and by x ray examination

The progress of healing is observed by subsequent examinations with a portable x ray machine and the apparatus must not be disturbed when the x ray picture is being taken The progress of healing should not be tested by attempted movement of the fragments Callus appears normally in the roentgenogram in about thirty days The skeletal traction may be removed as soon as callus appears and skin traction with adhesive plaster and diminished weight may be substituted From thirty to sixty days after injury it may be that healing will have progressed sufficiently to permit the application of molded plaster splints or a walking cast and the patient may be allowed up on crutches

Physiotherapy in all types of fractures described herein should be started early and should be intelligently directed toward overcoming and repairing the pathologic conditions

The extremity is kept elevated to assist the return circulation and diminish swelling Heat is applied to improve the circulation in both directions The patient is instructed to move the toes and the foot frequently Light superficial stroking massage beginning at the toes and working back to the lower part of the thigh may be applied for a few minutes several times daily by nurses This light stroking is designed simply to assist in the removal of the excess fluids in the tissues and must be applied at once and kept up until the swelling has disappeared If physiotherapy is not instituted early and if new inflammatory tissue is allowed to form it is then too late to hope to remove the new tissue The greatest value of physiotherapy after permanent changes have occurred lies in its psychic effect on the patient and the encouragement of voluntary use of the part which at a later date is the best physiotherapy

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tenor malleolus) the internal and external lateral ligaments and the tibiofibular ligament (Fig 396 a) The internal malleolus lies at a level somewhat anterior and proximal to that of the external malleolus and the internal lateral ligament runs from it to the astragalus and the superior margin of the scaphoid The external lateral ligament binds the external malleolus to the lateral margin of the astragalus and os calcis The tibiofibular ligament is especially strong and tough holding the surfaces of contact of the lower ends of the tibia and fibula firmly together If and when it gives or is torn it permits a dissociation or separation of these surfaces The posterior articulating margin of the tibia is particularly liable to injury it is longer and projects farther than is generally supposed (Henderson)

**Pathology**—When the ankle is forced beyond its normal range of abduction the first structure to yield is either the internal lateral ligament or the internal malleolus If the internal lateral ligament is not ruptured and holds fast a *transverse* fracture results at the tip middle or base of the internal malleolus Occasionally the fracturing force is insufficient to cause further damage However when it persists in intensifying the astragalus and foot, now unrestrained are jammed against the external malleolus If the tibiofibular ligament gives as is customary, there is a slight separation of the tibia and fibula but more especially there is a lateral displacement of the astragalus and external malleolus throwing a cross strain on the shaft of the fibula above the level of the ligament and a fracture results somewhere in the lower third or at times even

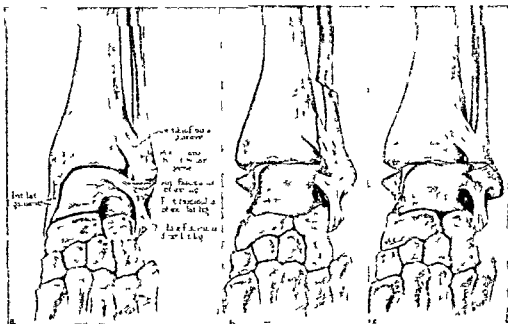


Fig 396—*a*, Diagrammatic illustration of the ankle joint and its ligaments Note the position of the tibiofibular ligament *b* abduction fracture with (1) fracture of internal malleolus (2) laceration of tibiofibular ligament and separation of tibiofibular articulation (3) fracture of shaft of fibula and (4) lateral displacement of astragalus *c* abduction fracture with intact tibiofibular ligament. NOTE. (1) Fracture of internal malleolus (2) fracture of external malleolus near its base and (3) lateral displacement of astragalus

**Abduction Fracture.**—Abduction fracture deserves prior consideration because it is the fracture in which displacement is likely to be greatest, complete and accurate reduction is most essential, and bad or poor results are not sufficiently infrequent

**Etiology**—The usual cause of an abduction fracture is a fall on the foot extended laterally away from the vertical axis of the body, but quite frequently, particularly in industrial or athletic accidents the foot may be held firmly and immovable as in a vise and the leg and body weight thrown laterally with the ankle as a pivot, forcing the ankle beyond the normal limits of abduction

in the middle or upper third (Fig 396 b) On the other hand if the tibiofibular ligament holds a fracture of the base of the external malleolus occurs with lateral displacement of the astragalus (Fig 396 c) and there may be a fracture of the lateral margin or external articulating surface of the lower end of the tibia as well In either case there always results a lateral dislocation of the astragalus to a greater or lesser degree

In the severe types of abduction fractures, forcible plantar flexion may be present, and a fracture of the posterior articulating surface of the tibia may occur which will permit posterior dislocation of the astragalus or talus as well Compound or open abduction fracture is occasionally observed Fractures from abduction may therefore result in

- 1 Fracture of the internal malleolus.
- 2 Fracture of the internal malleolus or rupture of

the internal lateral ligament with fracture of the fibula (shaft or malleolus), division of the tibiofibular ligament and lateral displacement of the astragalus (Figs 397, 398 and 399).

3 Fracture of the external articulating surface of the tibia or a fracture of its posterior margin; if the latter, posterior dislocation of the ankle may occur

**Diagnosis.**—The history of the accident and inspection of the ankle will usually suffice to arouse suspicion of a fracture. Pain and swelling about the ankle with inability to bear weight make the diagnosis of fracture fairly obvious. Because of the swelling, deformity may not always be readily detected. In the milder cases local swelling about the internal malleolus may be the only sign. When there has been lateral displacement, the external malleolus with the foot and heel may be definitely abducted and the ankle broadened. When there has been posterior displacement of the astragalus, the foot is plantar-flexed, and the heel is more prominent and farther posterior to the tibia than in the normal foot. Persistent or painful examination is never justifiable, as a roentgenogram is invariably necessary for accurate diagnosis. Simple, gentle palpation over the malleoli and bony prominences should suffice. Local tenderness over bone should be considered pathognomonic of fracture until proved otherwise roentgenologically. To elicit crepitus is cruel and is never indicated. Any swelling about the malleoli, even in the absence of other symptoms or signs, necessitates an x-ray examination; otherwise many fractures will be missed. The exact lesion can be determined only by the roentgenogram.

**Treatment.**—This fracture should be considered as an emergency, as it brooks no delay in its treatment. A roentgenogram should be taken before reduction is attempted. For transportation and immobilization purposes until reduction can be effected, well padded boot splints or a simple pillow splint will suffice. Morphine should be given for relief of pain.

**Anesthesia.**—In cases of fractures with but little displacement, no anesthetic is necessary. In the severer types, however, complete relaxation is highly desirable, if not essential. Local anesthesia will suffice therefore only in selected cases. Spinal anesthesia or sodium pentothal is ideal. When these

are contraindicated, general inhalation anesthesia must be used.

**Reduction.**—When there is only a fracture of the internal malleolus, local anesthesia may be used, and any displacement may be corrected by inversion of the foot, bringing the fragment of the tip up to the base of the malleolus. Molded plaster splints or a short plaster cast with a walking iron is applied for immobilization purposes.

In the severer types of fracture the deformity and the position of the foot and heel



Fig 397—Abduction fracture. NOTE (1) Fracture of the internal malleolus (transverse), (2) lateral displacement of the astragalus (3) fracture of the external malleolus with lateral displacement. There is no separation of the articulation between the tibia and fibula, & c., the tibiofibular ligament is intact

are guides for the measures required for reduction. The roentgenogram, however, will be the best criterion. While an assistant steadies the leg in the upper third and the knee is flexed to relax the gastrocnemius muscle, the heel and toes are grasped by the operator, and traction is made on the heel to overcome the contraction of the achilles tendon, at the same time correcting any upward proximal displacement of the astragalus. The foot is brought forward, if necessary, to a position of dorsiflexion at a right angle with the long axis of the leg. When



there is backward displacement of the astragalus and fracture of the posterior margin of the lower end of the tibia another assistant should push downward on the lower end of the tibia to obtain complete reduction. The foot is then adducted—maintaining the 90 degree dorsiflexion—to correct the lateral displacement of the external malleolus and astragalus. This adduction should not be as Murray has pointed out an extreme overcorrected position for when the tibiofibular ligament has been torn overcorrection

toward each other so as to correct any remaining lateral deviation of the astragalus and external malleolus and any tibiofibular diastasis. All posterior and lateral displacement should be completely corrected. When this reduction takes place early no great hurry or exhibition of strength is necessary. Gentle steady easing of the fragments back into position is the chief desideratum.

Reduction is maintained by the application of molded plaster splints (Fig 400) or a cast from the toes to the knee in the

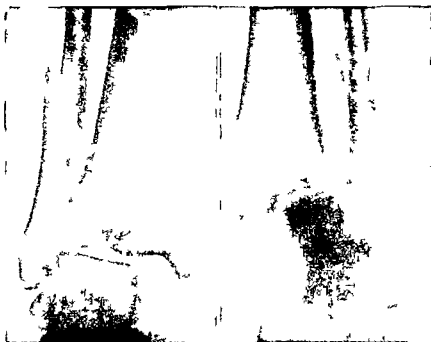


Fig 398

Fig 399

Fig 398—Abduction fracture. NOTE: (1) Laceration of the internal lateral ligament (2) lateral displacement of the astragalus (3) separation of the articulation of the tibia and fibula (4) laceration of the tibiofibular ligament and (5) comminuted fracture in the middle and lower third of the fibula.

Fig 399—Abduction fracture (anteroposterior view). NOTE: (1) Fracture of the internal malleolus (2) lateral displacement of the astragalus (3) rupture of the tibiofibular ligament, (4) marked separation of the articulation of the tibia and fibula and (5) oblique fracture of the lower end of the fibula, the external malleolus being displaced laterally with the astragalus.

will angulate the astragalus against the external malleolus and cause a persisting separation of the tibia and fibula at their articulating margins resulting eventually in painful weight bearing. The inversion should be to the position commonly used to correct a severe grade of flatfoot; i. e. the longitudinal axis of the tibia should pass through the center of the talus. Finally, with an assistant holding the foot in reduction direct pressure may be made by the heels of the hands against the malleoli forcing them

severe grades of displacement the flexed knee may be included. The fluoroscope may be used as an important aid in obtaining complete reduction. Often the ankle is so swollen thick or fat and the bones are so superimposed that accurate fluoroscopic vision is difficult. In all cases since complete reduction is so essential a postreduction roentgenogram should be taken both anteroposterior and lateral views. This may be repeated at three to five day intervals for corroboration of the maintained reduction until

union has begun. Occasionally, stereoscopic plates may clear up a doubtful detail.

*After-Care.*—It is now well recognized that reduction is simply the beginning of fracture treatment and that proper after-

that end. When it seems certain that union has begun and the swelling of the soft tissues has largely receded, the cast is removed and a skin-tight plaster cast applied up to, but not including, the knee. A walking iron or



Fig. 400—Actual molded plaster splints (1) Lateral plantar medial or U-shaped No. 1 splint, (2) long posterior shell with foot piece No. 2 splint

care so as to obtain complete restoration of function of the part plays an equally important role in obtaining a satisfactory end result. Though a more or less definite routine must be kept in mind, each case should be conducted solely on its individual requirements. The essential elements of after-care are immobilization that is sufficiently long to obtain union, early active motion, physiotherapy, protected weight bearing and prevention of late eversion of the foot or flatfoot.

If a simple cast is applied for primary restraint, it should be lightly padded about the ankle, and in the severer types of fracture it should be allowed to remain in place for from eight to twelve days, until some union between the fragments has begun. This should not be an arbitrary set-up, and the time should vary with each case. During this period, however, the patient should be encouraged to move his toes periodically as a regular exercise. With this effort there is bound to be contraction of other muscles of the leg beside the extensors and flexors of the toes—even if no movement of the foot is possible, and atrophy and weakness from disuse are thus in part avoided and the eventual return of function is very materially hastened. From the beginning, the patient should be led to realize that he must regain function for himself, the surgeon and physiotherapist can be but adjuncts toward

stirrup may be incorporated so that weight bearing and active use of the extremity may be started (Fig. 401). This method should be used with caution, as the weight is not borne by the foot and ankle but by the upper third



Fig. 401—Walking iron or stirrup

of the leg. Paralysis of the peroneal nerve and ulcers due to pressure have been known to develop. If a walking stirrup is used, the patient should be kept under close observation. The advantages of this treatment lie

in the early return of function as a result of early maximum voluntary use

When molded splints are used one or both may be cautiously removed daily and guided active motion and light stroking massage begun after from five to ten days. This should be done by the surgeon himself or a competent assistant. The interval of time after reduction before these measures are instituted must vary with the individual fracture. A fetish for early action must not overrule the need for sufficient immobilization.

The cast or plaster splints may be discarded after five or six weeks. Occasionally a posterior shell or splint may be needed for an even longer interval. Daily massage, bathing and regular active exercises by the patient should be instituted and simple weight bearing cautiously allowed. In fractures involving the articulating surface of the posterior margin of the lower end of the tibia weight bearing should be delayed until solid union is certain; this may require ten to twelve weeks. When unprotected weight bearing is permitted there is a great tendency, especially in heavy subjects toward eversion of the foot and actual flatfoot as a result of weakness of the ligaments and muscles because of disuse. Therefore shoes with the inner or medial margin of the sole and heel raised from  $\frac{1}{4}$  to  $\frac{1}{2}$  inch (0.5 to 1 cm.) should be worn. At times a light brace for the ankle may be necessary or an outside iron with a T strap may be useful. Crutches may be dispensed with as soon as weight bearing is painless and the muscle strength has returned. In cases in which pain is persistent or function is regained slowly diathermy may be added to the physiotherapy armamentarium. Passive motion has no place in the after treatment. The early and complete restoration of function hinges largely on the patient's active cooperation in persistent use and exercise of the foot and leg and on the surgeon lies the onus of obtaining full cooperation.

A fracture which involves the internal malleolus alone presents a comparatively minor problem. The time of immobilization may be shortened to three weeks and weight bearing is begun early. In many cases the patient may be permitted to return to work before the completion of treatment pro-

vided no strenuous physical activity is involved.

**Tibiofibular Diastasis**—Diastasis of the lower tibiofibular articulation occurs especially with fracture of the internal malleolus and lower third of the fibula. The symptoms of fracture may overshadow it. Diastasis may be recognized by tenderness over the tibiofibular joint, widening of the distance between the malleoli and properly taken roentgenograms. Diastasis is very likely when the fracture of the fibula is 2 to 3 inches (5 to 8 cm.) or more above the ankle joint with fracture of the external articulating surface of the tibia.

Recognition of diastasis and early reduction and maintenance of reduction until ligament and fracture healing occurs are imperative or disability from permanent widening of the ankle joint and instability of the distal end of the fibula will result. Reduction is easy unless there is interposition of tissue. When interposition is present open operation through an anterior incision over the joint is indicated. The displaced tissue must be replaced or removed and the tibia and fibula held in position by a screw introduced through a small lateral incision. After union is complete the screw is best removed or painful dorsiflexion may persist. Full weight bearing should be delayed until twelve to sixteen weeks after the accident.

**Late Cases**—When a patient is presented for treatment a few days or longer after the accident with persistent displacement and deformity the problem of reduction and treatment so as to obtain complete recovery may be exceedingly difficult. Long standing muscle contraction may make manipulatory reduction impossible and even if possible it may be difficult to maintain. Fractures involving the posterior margin of the lower end of the tibia with or without posterior dislocation of the astragalus will tax the ingenuity of the surgeon. Skeletal traction by means of a spike or pin through the os calcis should be tried and is often successful. Overhead traction from the plantar surface of the foot the weight of the leg and lower extremity acting as counter traction has been used (Gerster). Open operation with internal fixation followed by traction may have to be resorted to.

**Prognosis**—When a satisfactory reduction

has been effected early and has been well maintained in a patient who cooperates well in the after-care excellent functional results can be expected. The cases of posterior dislocation of the astragalus with fracture of a large fragment of the posterior margin of the tibia may present some late disability due to excessive callus in and posterior to the joint. Fortunately these cases are comparatively rare. When reduction is only barely satisfactory and when it has been performed late in an aged and arthritic person the prognosis should be guarded as some permanent disability is likely to follow or subsequent arthrodesis may be necessary. Furthermore failure of the patient to cooperate sufficiently in the active use of the foot and ankle may lead to some limitation of motion in the ankle which may or may not produce disability.

**Malunion**—Malunion results from an unrecognized untreated or improperly treated fracture permits persistent deformity and causes the development of a painful or useless ankle joint and disability of the patient. Open operation for correction of the malposition is necessary usually with some type of arthrodesis of the ankle.

**Other Complications**—A persistently painful ankle joint may occasionally result from an abduction fracture even when the reduction is excellent or seems adequate. Murray has suggested that this disability may be due to a persistent tibiofibular diastasis caused by the overadducted or everted position of the foot in reduction angulating the astragalus against the external malleolus. In other instances persistent pain may be due to a post-traumatic arthritis secondary to some focus of infection or metabolic disturbance. Diathermy, elimination of foci of infection and proper diet are essential. A few patients although they complain have no major loss of function and are able to work. When there is considerable disability arthrodesis may have to be considered.

**Pott's Fracture**—The fracture originally described by Pott was a severe grade of abduction fracture. The term Pott's fracture in recent years has been very loosely used to indicate all ankle fractures all abduction fractures at the ankle or abduction fractures with lateral and posterior displacement of the talus. Until unanimity of opin-

ion as to its use and definition is reached it fails to be an accurate medical term.

**External Rotation Fractures—Etiology**—External rotation fractures are caused by short falls on the foot the foot striking some object such as a curb that twists it in extreme external rotation or else with the foot fixed the leg and body are internally rotated at the ankle twisting the foot laterally.

**Pathology**—When the foot is rotated forcibly externally the twist is first transmitted to the lower end of the fibula causing a oblique fracture of its lower third. If the force is continued the internal lateral ligament is ruptured or as a abduction fractures the tip or middle of the internal malleolus may be fractured and the fragment displaced anteriorly and laterally. At the same time the rotation of the astragalus is likely to crack off the posterior margin of the lower end of the tibia. Very rarely posterior dislocation of the astragalus occurs from external rotation alone but the forces of abduction extend (plantar flexion) and external rotation are often combined to cause fracture and the characteristic lesions may be associated. There also may be lacerations of the lower tibiofibular articulation or fracture of the external articular surface of the tibia. If this occurs it takes place at the time of fracture of the fibula, and the fibula fracture may then be located in the middle or upper third.

The usual lesions are oblique fracture of the fibula oblique fracture of the fibula with rupture of the internal lateral ligament or fracture of the internal malleolus with or without posterior marginal tibial fracture (Fig. 102).

**Diagnosis** of an external rotation fracture rests on the history of the accident and the roentgenogram. There is usually swelling about the malleoli and ankle but no characteristic deformity and the displacement is seldom more than slight. There will be tenderness over the internal malleolus when it is fractured over the fibula at the point of fracture and posterior to the internal malleolus when the posterior margin of the tibia is involved. The fracture of the fibula may not be revealed except in the lateral roentgenogram when high in the middle and upper third it may be missed unless the entire leg is x-rayed.

**Treatment**—To reduce the fracture it is necessary to make only slight traction and place the foot in moderate adduction and inversion to bring the fragments into apposition. A cast or molded plaster splints are then applied in this position with the foot in full 90 degree dorsiflexion.

After care follows the outline previously

given for abduction fractures. The cast and splint may be discarded after three or four weeks.

Prognosis is good in a case of simple external rotation fracture. Recovery is complete in from six to eight weeks and work may be resumed by the end of three months—often at the conclusion of treatment.

**Adduction Fractures—Etiology**—A fall on the foot in adduction or an adduction twist of the ankle though more likely to cause sprain may produce a fracture

parent. Unless the history of the accident is clear the diagnosis of an adduction fracture rests on the roentgenographic evidence as the lines of fracture are usually characteristic.

**Treatment**—In fracture of the external malleolus alone or bimalleolar fracture without displacement immobilization in a cast or splints is all that is necessary. Restraint need be employed for only three weeks. If a flail joint is present it may be quite difficult to restore the ankle joint accurately. Fluoroscopic reduction may be an advan-



Fig 402.—External rotation fracture. At left oblique fracture of the lower end of the fibula. At right fracture of the internal malleolus.

**Pathology**—Forced adduction at the ankle causes first a fracture of the external malleolus at the level of the upper border of the astragalus. The astragalus then impinges against the internal malleolus and, if the trauma is sufficiently great, produces a fracture of its base. The line of fracture extends longitudinally and upward into the shaft quite different from fracture of the internal malleolus from external rotation and abduction. When this fracture is complete the entire mortise of the ankle is destroyed, and a flail joint may be produced. Clinically two types of adduction fracture are observed: (1) fracture of the external malleolus alone and (2) bimalleolar fracture.

**Diagnosis**—The evidence of fracture will be swelling about the ankle particularly at the malleoli with tenderness over the fracture areas. Very seldom is a flail joint ap-

parent. Unless the history of the accident is clear the diagnosis of an adduction fracture rests on the roentgenographic evidence as the lines of fracture are usually characteristic. **Treatment**—In fracture of the external malleolus alone or bimalleolar fracture without displacement immobilization in a cast or splints is all that is necessary. Restraint need be employed for only three weeks. If a flail joint is present it may be quite difficult to restore the ankle joint accurately. Fluoroscopic reduction may be an advan-

After care should follow the measures previously described for abduction fractures. The prognosis is good unless the apposition of a bimalleolar fracture has not been sufficiently exact.

**Extension Fractures—Etiology**—A fall or jump on the extended foot is the usual

cause of an extension fracture. It occurs at times in games such as tennis or basketball from jumping in the air for a ball.

**Pathology.**—With the foot extended or plantar flexed the astragalus is driven against the posterior margin of the articulating surface of the tibia, sometimes called the posterior malleolus (Desrot Henle son Cotton), which is broken off. The fracture usually involves the articulating surface of the tibia but very rarely the posterior surface alone. The posterior tibial tubercle may be split off from traction by the inferior posterior tibiofibular ligament. When the force is con-

siderable, a sprain unless roentgenograms are taken. Though both anteroposterior and lateral views should be made, the lateral roentgenogram will demonstrate the lesion. With posterior dislocation of the astragalus, the prominence and backward position of the heel will be pathognomonic.

**Treatment.**—Even if there is little or no displacement, it is best to immobilize the ankle in at least 90 degree dorsiflexion. In displaced fracture and especially when some



Fig. 403.—Adduction fracture of extreme grade. (1) laceration of the external lateral ligament. (2) fracture of the internal malleolus at the base with extreme medial displacement and (3) complete medial displacement of the foot and astragalus.

time 1 after a posterior talar fracture has occurred posterior dislocation of the astragalus may result (Figs. 401 and 403).

**Diagnosis.**—This type of fracture if posterior dislocation of the ankle is not evident and unless roentgenograms are carefully taken may easily be overlooked. There may be broadening of the ankle in the anteroposterior diameter and ecchymosis and tenderness on palpation behind the internal malleolus. The foot may be held in extension (plantar flexion), and flexion may be painful. The lesion may be considered a simple

posterior dislocation of the talus is present strong traction on the heel should be made to effect reduction with the knee flexed to relax the gastrocnemius muscle and as much dorsiflexion as possible obtained. If the fragment is large and there is not enough articulating surface of the tibia left intact to hold the talus in place after reduction, open fixation with bone or metal pegs or osteoclasis pin traction will be necessary. When the articulating surface is involved, there should be at least four weeks of restraint. After care should follow the outline indicated for ab-

duction fractures. Weight bearing should be cautiously permitted and should be avoided for fully ten weeks if the talus is displaced.

**Prognosis** depends on early and complete reduction of a displaced fragment. Occasionally when there is a large fragment and reduction is satisfactory, excessive callus may lead to some restriction of and pain with ankle motion, but rarely will operative intervention be necessary for relief. However, in the neglected case when displacement of the posterior malleolus persists and manipulatory reduction is impossible, open operation with replacement and fixation of the

tion but a definite diagnosis can be made only from the lateral roentgenogram. It should not be confused, however, with a displaced internal malleolus. Stereoscopic x-ray pictures will differentiate between the two.

**Treatment**—Immobilization of the foot in extension or plantar flexion is usually advisable for adequate reduction, as a rule there is but little displacement. Resection of the fragment is rarely necessary.

**Compression or T Fracture of the Lower End of the Tibia—Etiology**—A fall from a height on the foot or heel in such a way as to force the astragalus against the lower end

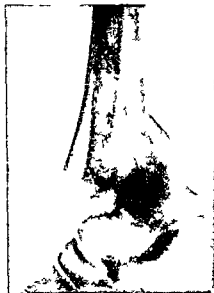


Fig 401



Fig 402

Fig 401—Extensive fracture (lateral view). Note (1) Fracture of the posterior articulating margin of the tibia with displacement upward; (2) posterior dislocation of the astragalus and (3) long oblique fracture of the fibula in the lower third with marked posterior displacement of the lower fragment.

Fig 402—Extensive fracture after reduction.

fragment will be indicated. For persistent long-standing pain and disability arthrodesis is advisable.

**Flexion Fractures—Etiology**—A fall on the heel with the foot in flexion (dorsiflexion) is accountable for the rare incidence of this lesion.

**Pathology**—The weight and force of the fall on the heel drives the talus or astragalus against the anterior articulating surface of the lower end of the tibia and breaks it off.

**Diagnosis**—Localized pain and swelling over the anterior surface of the ankle will be present with restriction of flexion and exten-

sion of the tibia may cause a splitting or T fracture of the tibia.

**Pathology**—The impact of the astragalus against the lower end of the tibia may produce numerous lines of fracture or a T type lesion. There is usually lateral and medial displacement of the fragments. There may be a complete laceration of the tibiofibular ligament with the astragalus driven up between the tibia and fibula and the lateral margin of the tibia fractured. A fracture of the fibula in addition is almost always present and very often there is also a fracture of the calcaneus or os calcis or even in the astragalus.

**Diagnosis**—So much swelling and deformity of the ankle usually results that the exact lesions cannot be determined without an

**X-ray picture** When shortening of the distance between the plantar surface of the foot and the malleoli with broadening of the ankle is observed this type of fracture may be suspected

**Treatment**—Traction on the heel with the knee flexed will usually suffice for reduction followed by bilateral pressure on the malleoli. A cast may not be sufficient to maintain reduction and a traction spike or pin through the os calcis is usually advisable. Reduction may have to be accomplished entirely by os calcis pin traction. Four or five weeks of traction should suffice and no weight bearing should be permitted until at least three months after the accident.

A multiple fracture of this type of injury should make the prognosis for complete return of function guarded since late arthritis may be necessary.

**Atypical Fractures**—Fractures from direct injury or trauma are mentioned merely for the sake of completeness. The majority of them are quite atypical lesions and must be treated according to individual merits and indications.

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## FRACTURES OF THE BONES OF THE FOOT

**Functional Considerations**—When fractures of the foot are considered the highly specialized function of this organ for bearing the body weight must be kept in mind. Its distinctive anatomical feature is the plantar arch which serves as a spring to cushion the impact of locomotion. Weight is transmitted to the ground at three points

the heel the head of the first metatarsal and the outer border of the foot (fifth metatarsal and cuboid bones). The weight thrust of the body is received by the astragalus from the tibia distinctly to the medial side of the mid axis of the foot and from this there results a tendency for the skeletal tripod to topple over to the inner side with the production of flatfoot. Normally the foot is maintained in a correct weight bearing position by the supporting action of the muscles and ligaments and the strength of the plantar arch is derived from these rather than from the architectural arrangement of the skeleton. When the muscles are weakened from any cause the foot pronates, the arch sags and the foot tires quickly and becomes painful. The chief support of the arch is provided by the tibialis anticus, the tibialis posticus and the long flexor muscles of the toes. Following prolonged immobilization by splints these muscles require special training to restore their strength.

From what has been said it will be seen that certain structural relationships are necessary for proper function of the foot and that any disturbance of these such as may result from a fracture of the tarsal or metatarsal bones is likely to prove disastrous. Therefore in the treatment of such injuries it should be the guiding principle to preserve normal weight bearing lines and to restore as completely as possible the skeletal contour of the plantar arch.

Because of the effect of gravity the return flow of blood and lymph from the leg is maintained with considerable difficulty. Following fractures of the bones of the leg or foot there is great circulatory stasis and swelling. The swelling is usually most marked in the foot and ankle and is apt to persist for a long period unless special measures are taken to overcome it. Of the various methods to stimulate the circulation early active use of the foot is among the best. This may be obtained by incorporating a steel walking stirrup of the type devised by Blier in the plaster casing that is commonly employed to maintain alignment after reduction of the fracture (Fig 406 A B and C).

When splints have been removed and active movement and use of the foot are permitted the foot should be supported temporarily in correct weight bearing position by





**Frequency of Injury of the Bones of the Foot**—An idea of the frequency of the various injuries of the tarsal bones may be gained from the following table which is based on a study of 4066 patients with skeletal injuries admitted to the Massachusetts General Hospital between the years 1923 and 1930. The total number of fractures and dislocations was 5436. Fractures of the phalanges and metatarsals are not included in the table as many of these were multiple injuries and could not be classified easily. Fractures of these bones occurred with much greater frequency than those of the tarsal bones.

DISTRIBUTION OF INJURIES OF THE TARSAL BONES

	No. of patients	Per cent of total injuries
Tarsometatarsal dislocation	3	0.07
Fractures of cuboid and cuboid	10	0.20
Fractures of scaphoid	17	0.40
Subastragalar dislocations	9	0.20
Total dislocations of astragalus	3	0.07
Fractures of astragalus	17	0.40
Fractures of calcaneus	59	1.30
Total	118	2.61

**Fractures of Single Phalanges**—Fractures of single phalanges of the toes such as result from striking the toe against a solid object or from the fall of a weight are usually unimportant injuries if not compound and rarely cause more than temporary disability. Bony deformity as a result of the fracture is unusual but care should be employed to prevent the toe from assuming a hammer toe position.

Fractures of a single phalanx may be splinted either by strapping the injured toe to its neighbor or by applying cardboard or felt roll splints. The use of an extra heavy stiff leather sole is an aid to early weight bearing. When the distal phalanx of the great toe is involved the injury may be quite painful largely because of the formation of a hematoma under the nail. Relief may be obtained by drilling the nail and evacuating some of the fluid.

**Multiple Fractures of Phalanges and Metatarsals**—Multiple fractures of the forefoot are usually produced either by the fall of a heavy weight or by the passage of a wheel over the foot. The trauma is generally severe and distributed over a wide area

so that the phalanges or metatarsals of several digits and not infrequently of all the digits may be implicated. In such injuries the damage of the soft parts and accompanying impairment of the circulation may represent more urgent problems from the standpoint of treatment than the lesions of the bones. The fractures are often compound, the wounds must be cleaned and the devitalized tissue must be trimmed away in a manner similar to that employed in the treatment of compound fractures anywhere. Lacerated tendons should be identified and repaired and the skin edges sutured loosely. The lesser toes are of little functional sig-

nificance and should be amputated when their circulation seems imperiled but every effort should be made to save the great toe.

The amount of bony displacement in the multiple fractures due to crushing injuries is often great and prompt treatment is necessary to secure proper alignment of the bones. This is best accomplished by applying traction to the toes in conjunction with a banjo splint. The latter is a bent wire frame incorporated in a plaster casing. The toes offer too small a skin surface to make adhesive traction effective and consequently direct skeletal traction by means of small wires or needles passed through the distal phalanges must often be used. The wires are connected to the banjo frame of the splint by rubber elastic bands.

This apparatus brings about realignment of the bones and maintains position while at the same time permitting exposure of the wound for dressings. Union of the fractures requires from four to six weeks but weight bearing with the aid of crutches cannot usually be permitted before the end of from eight to ten weeks. Massage to improve the circulation and active mobilization of the

toes should be begun as early as the state of the wound permits

**Fracture of the Tarsal Scaphoid**—Fracture of the tarsal scaphoid is uncommon but the injuries are almost always identical. The fracture is produced by an impact against the ball of the foot usually by a fall in which

open up the space occupied by the scaphoid bone while at the same time digital pressure is exerted on the dorsally displaced fragment. Following reduction the foot must be fixed by the application of a plaster casing in the position of equinus. Fixation may be removed at the end of six weeks but weight

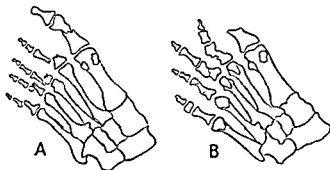


Fig 407.—Tracings of the roentgenograms of multiple fractures of the phalanges resulting from a crushing injury. A Appearance of the foot immediately after the injury. B appearance one year later showing healing of the fracture. The great toe was amputated at the middle of the proximal phalanx. A good working foot was obtained.

the person lands with his weight on the forefoot. The force is received on the metatarsal heads and transmitted backward to the anterior tarsal bones and the scaphoid situated at the apex of the arch is crushed between the head of the astragalus and the

bearing should not be permitted until the end of from ten to twelve weeks.

**Fracture of the Astragalus**—Fracture of the astragalus is a rare and very disabling injury. The most common variety involves the body of the bone or the junction

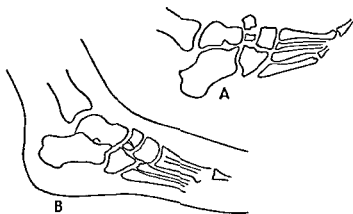


Fig 408.—Fracture of the tarsal scaphoid. A Tracing showing the typical dorsal displacement of the superior fragment. B the same case after closed reduction and fixation in a plaster in the equinus position.

cuneiform bones. There results a comminuted compression fracture of the scaphoid with the dislocation dorsally of a large superior fragment.

When the patient is seen early reduction can usually be accomplished by manipulation under full anesthesia. The forefoot must be forced into extreme plantar flexion to

of the body with the neck and consists of a vertical split extending downward in the frontal plane from the superior articular surface to the subastragalar joint. There may be more or less comminution.

The fracture is usually produced by striking on the foot after a fall from a height, the impact of the ground and the weight thrust

of the body coming into opposition in the region of the astragalus where it arches forward from the calcaneus to the scaphoid. The trauma is severe and gross deformity usually results, the large posterior fragment being usually dislocated backward out of the ankle joint mortise and also frequently rotated inward or outward as well. Owing to the thin envelop of soft tissues about the ankle joint these structures are often torn and the injury is rendered compound. If not compound in the beginning it may easily become compound by necrosis of the overlying skin from pressure of the unreduced fragment beneath.

The treatment of this injury nearly always necessitates operative removal of the astragalus. Owing to the fact that the posterior fragment is usually devoid of blood supply there is little chance of a good result

importance arises in certain cases of injury to the foot as to whether a small triangular piece of bone revealed in the lateral roentgenogram as lying posterior to the body of the astragalus represents an actual fracture or is only the os trigonum, an anomalous bone formed by the failure of a separate center of ossification to fuse with the body of the astragalus which is present in about 10 per cent of normal persons without causing symptoms. In answering this question it is important to note whether or not the signs of injury are localized in this region and also to have roentgenograms of the normal foot for comparison. When a similar shadow is present in the opposite foot it is probably not a fracture.

**Fractures of the Calcaneus**—On account of their frequent occurrence and their disabling effect fractures of the calcaneus

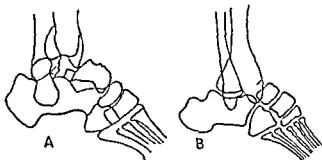


Fig. 409.—A complete fracture-dislocation of the astragalus. A, Roentgenographic appearance immediately after injury. Note the posterior and rotary dislocation of the body of the astragalus. The neck of the astragalus is still in situ. B, appearance one year after astragalectomy.

from its replacement, even when this can be accomplished without danger of infection as it is apt to undergo aseptic necrosis and later crumble under the superincumbent weight of the body. When the fracture is compound the fragment is generally so soiled that its replacement would be unsafe. Astragalectomy does not give a normal foot but when performed properly yields a useful and pain-free foot. Removal of the astragalus should be combined with careful debridement and extensive lavage of the wound when the injury is compound. A plaster casting should be applied from toes to thigh with the knee flexed, the foot well displaced backward under the tibia and in a position of equinus. Fixation is necessary for from eight to ten weeks and a brace should be fitted when weight bearing is to be permitted.

A question of considerable medicolegal

deserve to be ranked as the most important bony injuries of the foot. They constitute between 1 and 2 per cent of all skeletal injuries and industrial liability insurance companies are in agreement that they give rise to relatively greater disability than almost any other variety of fracture.

A fracture of the calcaneus is generally caused by a fall from a height, the person striking on one heel. The height does not need to be great and in older persons such an injury may follow a fall of 4 or 5 feet. Occasionally it may be caused by a twist of the foot. The fracture is bilateral in about 10 per cent of the cases. It is rarely compound. In falls of considerable distance it is frequently associated with other skeletal injuries, the most common being compression fractures of the vertebrae, fractures of the shaft of the femur or fractures of the pelvis.

The fracture generally involves the body of the calcaneus but occasionally the apophyseal portion of the tuberosity alone is implicated a fragment to which the tendo achillis is attached being avulsed and pulled upward by this muscle. Fractures of the body of the calcaneus may be divided into crush fractures and fissure fractures. The crush fractures are characterized by extreme comminution of the entire calcaneus and by gross deformity. The fissure fractures are also comminuted but less so than the true crush fractures and one or two chief fracture lines can usually be distinguished. These are generally in the form of the letter V with the limbs extending upward from

The diagnosis of fracture of the calcaneus can usually be made from the history of a fall followed by inability to bear weight on the foot and pain in the region of the heel. On examination there is swelling about the heel local tenderness and occasionally abnormal mobility. Deformity can often be recognized in the form of shortening and elevation of the heel. The ankle motions are free, but the subastragalar movements are limited and painful.

The roentgen examination should include lateral anteroposterior and plantar views of the foot. The plantar view is made with the film under the heel and the tube directed in such a manner that the rays pass obliquely

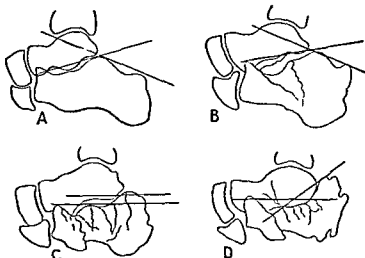


Fig. 410.—Tracings of roentgenograms of normal and fractured calcanei showing alterations in the relation of lines prolonging their superior surfaces. A Normal B slight defect C moderate defect D very marked defect.

the plantar surface of the calcaneus and spreading to enclose the posterior articular facet which is generally depressed or tilted.

There is usually considerable displacement which presents three characteristic features. The posterior process of the heel is displaced upward as a result both of the impact against the ground and of the pull of the gastrocnemius muscle. It is also driven forward so that the heel is shortened. Because the weight thrust through the tibia falls to the medial side of the longitudinal axis of the heel the foot tends to pronate under the impact of a fall and since the calcaneus is fractured when the heel is in eversion the posterior process is usually displaced laterally

downward and forward through the ankle. The normal foot as well as the injured one should be included in the examination in order to show the degree of displacement. The extent of the deformity may not be appreciated unless two lines are drawn on the film with a ruler: the first uniting the posterior superior tubercle of the calcaneus and the posterior tip of the articular facet and the second the anterior superior tip of the calcaneus and the posterior articular margin (Fig. 410). Normally these two lines intersect each other at an angle and the degree of the angle registers the oblique axis of the posterior heel process. In case of fracture this angle is much increased and if there is considerable deformity the lines may fail to

intersect and instead become parallel. The restoration of the normal angle is one of the chief objectives of efforts at reduction.

Failure to correct the displacement in fractures of the calcaneus gives rise to several different types of disability. The flattening and outward deviation of the heel disturbs the weight bearing mechanics of the foot with resulting pronation or flattening of the arch and symptoms of weakness and strain. The outward displacement of the calcaneus may lead to bony impingement against the lateral malleolus causing pain and limitation of motion. The fracture may produce so much irregularity of the superior articular facets as to limit function and cause chronic synovitis and pain. Lastly, the displacement may give rise to abnormal

plantar surface of the foot (Fig. 411 A). A weight of 15 pounds is usually sufficient but more may be required. After the traction weight has been connected a special pressure clamp is applied to the body of the calcaneus in the transverse diameter and the bone compressed strongly. Bohler has devised a special clamp for this purpose which is molded to restore the normal anatomical contour (Fig. 411 B) but a carpenter's C clamp serves almost as well. Layers of felt are applied between the clamp and the skin. The compression should not be maintained for more than a few minutes. The traction force tends to prevent recurrence of the deformity after the clamp has been removed.

The leg should be left in this apparatus for from two to three weeks at the end of

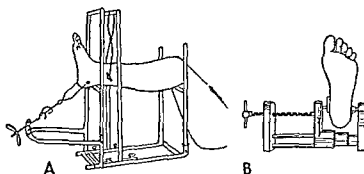


Fig. 411.—A Apparatus for reducing a fracture of the calcaneus by skeletal traction (after Bohler). B special clamp designed by Bohler to correct lateral spread of the calcaneus.

bony prominences on the plantar surface which may become painful pressure points.

The treatment of the fracture must aim to remove all of these possible causes of disability and the solution lies in correction of the deformity. This can be accomplished when the patient is seen soon after injury. General or spinal anesthesia is necessary. Skeletal traction is applied to the heel by means of a Kirschner wire inserted through the posterior process of the heel. A Thomas splint bent so as to allow 45 degrees of flexion at the knee is applied to the leg and suspended from an overhead frame. The leg is supported in the splint by strong canvas strips which extend distally to just above the heel. The spreader of the Kirschner wire is connected to a weight by a cord passing over a pulley, the line being adjusted so that it bisects the 90 degree angle formed by the longitudinal axis of the leg and the

which time a plaster casing is applied. The Kirschner wire may be removed through openings cut in the casing after the plaster has hardened. Because the wire passes directly through the seat of fracture there is considerable risk in leaving it in place more than three or four weeks. When applying the plaster it may be desirable to fix the ankle in a position of equinus in order to relax the gastrocnemius muscle and reduce its deforming pull on the calcaneus. Fixation of the foot in plaster should be maintained for a period of eight weeks. Baking, massage and exercise of the foot and ankle may be started after the removal of the plaster but weight bearing should not be permitted before the end of twelve weeks as the cancellous bone remains soft for some time and some of the correction might be lost.

While the chief aim in the treatment of fractures of the calcaneus is the correction

of bony deformity it must be admitted that it is often impossible on account of extreme comminution to achieve this objective as completely as in the case of many other skeletal fractures. Particularly is this apt to be the case in securing restoration of a smooth articular surface with the result that many of the patients continue to complain of pain even after the fracture has healed. The pain is aggravated by use of the foot and is worse in those persons whose work requires much standing or considerable physical effort. Examination generally dis-

of the subastragalar joint will be necessary to relieve the pain. This operation does not generally impair the usefulness of the foot as motion is preserved at the ankle joint and a certain amount of hypermobility develops in the midtarsal and anterior tarsal joints which compensates to some extent for the motion that is lost. As a matter of fact few of these patients have any appreciable motion of the subastragalar joint before operation and in any case the diminution of motion is but a small price to pay in return for the boon of relief from pain. Care must

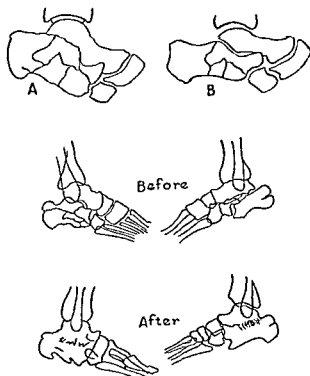


Fig 410—B lateral fracture of the calcaneus (A) before and (B) after subastragalar fusion. Before fusion. Note the marked displacement. After fusion. The patient can stand and walk all day without pain.

closes that the pain and tenderness are localized below the external malleolus so that the lateral movements of the foot are considerably restricted and that pain is produced whenever the attempt is made to manipulate the foot into a position of inversion. The roentgenographic examination reveals irregularity of the superior articulating surface of the calcaneus and narrowing of the joint space.

These are the signs of a chronic degenerative arthritis resulting from the traumatic changes in the joint and an operation to remove the cartilage and secure ankylosis

be taken during and after the operation to preserve the normal weight bearing lines of the foot. The operation of subastragalar fusion is so frequently required in cases of severely comminuted fractures of the calcaneus involving the articular surface that in certain recent cases it may be the better part of wisdom to anticipate the occurrence of future trouble by fusing the joint from two to four weeks following the fracture thus restoring the patient to usefulness at the earliest possible moment.

PHILIP D. WILSON

## BIRTH INJURIES AND FRACTURES AND EPIPHYSEAL INJURIES IN CHILDREN

**General Considerations**—Although injuries of bone in children are very similar in most respects to those which occur at an older age there are certain peculiarities and differences that should be noted.

Fractures may take place in utero or during the process of delivery and so be present at birth. The marked elasticity and the thick periosteum of growing bones tend to produce certain types of fracture such as the incomplete or greenstick fracture and the subperiosteal or buckling fracture. In children the epiphyses from which the bones grow may become separated from the shaft by trauma with possible interference with the growth of the bone. Fractures at certain places in the skeleton such as the middle of the clavicle the lower end of the humerus both bones of the forearm and the shaft of the femur are more frequent in children than in adults.

The prognosis in a case of fracture at this age is better in general than it is in later life. The good osteogenetic power of growing bone and the relatively smaller size of children's bones tend to result in strong and rapid healing in most cases and non union is rather infrequent. Of great importance is the tendency of growing bone to correct angulation and other deformities. Shortening of a considerable extent may be made up in the process of growth. On the other hand epiphyseal injuries in some cases may lead to premature union of the epiphysis and the shaft with a permanent shortening in the length of the bone. When this occurs in one of the bones of the forearm or the leg a serious deformity may result.

### INTRAUTERINE FRACTURES

A fracture of the bones may occur in utero and may be evidenced in the newborn by swelling and deformity at the site of fracture. The roentgenograms in such a case show signs of callus formation indicating that the fracture was present for some time before birth.

The condition may be due to (1) trauma to the abdomen of the mother especially in cases of oligohydramnios in which the small

amount of amniotic fluid is insufficient to protect the child in utero or to (2) osteogenesis imperfecta a congenital condition in which the bones are abnormally brittle and predisposed to fractures from slight trauma. The majority of intrauterine fractures result from this congenital fragility of the child's bones which is a hereditary condition in about 15 per cent of the cases. The fractures are usually multiple and the ribs and long bones are most frequently involved. Union takes place rather slowly with little callus formation and considerable deformity in most cases.

When evidences of intrauterine fractures are discovered at birth it is presumptive that the child is afflicted with osteogenesis imperfecta and only the most careful handling will prevent the occurrence of additional fractures. For several months the infant should lie constantly on a soft pillow and for a year or two after that should be kept fastened to a Bradford frame. No attempt to correct any deformities should be made until the child is older for fear of producing more fractures.

Although the cause of osteogenesis imperfecta is unknown and no particular treatment seems to benefit the bone condition the child should be placed under the best hygienic conditions of rest food and sunshine. Cod liver oil and calcium preparations should be administered to increase, if possible the lime content of the bones. Parathyroid extract does not seem to have any favorable influence on the condition.

**Intrauterine Amputations**—In rare instances the distal portion of an arm or of a leg of a newly born infant may be missing. The end of the affected member resembles the stump following a surgical amputation and may even show a granulating wound if healing was not completed before birth. The condition may be limited to the loss of one or more fingers but it may involve the major portion of a limb. In some cases the affected member may show one or more congenital furrows on the skin due to long pressure from bands that have caused scar formation in the subcutaneous tissue. This congenital deformity is usually associated with a condition of oligohydramnios which permits the umbilical cord or an adventitious amniotic band to become ensnared about



the limb. The resulting strangulation causes interference with the growth of the distal portion of the limb or even amputation.

The process of amputation probably occurs in the early months of gestation when the limbs are quite small and the missing part is usually not discovered but occasionally it has been found in the lochia. Where the constriction from the cord or band has

the child's bones more often it is (2) the result of trauma when delivery is difficult because of a contracted pelvis or malposition of the child.

In many instances the obstetrician may feel or hear the bone break but more often the condition is not discovered until some time after birth when attention is drawn to the part by pain, swelling and deformity. A



Fig. 413—Roentgenogram of newborn child showing multiple intrauterine fractures.

not been sufficient to cause an amputation the distal part of the limb may be atrophied and deformed with rudimentary fingers or toes.

**Obstetrical Fractures**—This term is used to designate all fractures of the bones of a child which occur during delivery. The etiological factor may be (1) some constitutional disease such as osteogenesis imperfecta which causes abnormal fragility of

roentgenogram will usually show a transverse fracture very often of the subperiosteal type with angulation but no displacement of the fragments. The bones most frequently affected by obstetrical fractures are the clavicle, humerus and femur. The skull may be broken by the obstetrical forceps.

The treatment of these fractures should consist of obtaining union by the simplest and most comfortable fixation dressing. The

outlook for a satisfactory anatomical and functional result is good. Any deformity tends to disappear rapidly in young growing bones.

*Clavicle*—Fractures of the clavicle usually occur in the middle third as a result of efforts to bring down an arm in a breech presentation or to free a shoulder in a difficult head presentation. The usual signs of this injury are tenderness, swelling, angulation and disuse of the part. A satisfactory dressing in such a case is a smooth and well applied Velpert's bandage which will hold the forearm in flexion with the shoulder fixed well back. Before this bandage is applied the skin should be powdered and covered with sheet wadding wherever the arm touches the chest wall. Fixation for two weeks is usually sufficient to obtain union.

The *humerus* is usually fractured at the junction of the middle and lower thirds of the shaft during manipulation of the arm in delivery. The usual signs of fracture are present, but displacement of the fragments is infrequent. The simplest treatment for this fracture is fixation of the arm in a slightly abducted position. A wedge shaped axillary pad extending from the axillary fold to the elbow is fastened to the chest wall with adhesive plaster. A small apposition splint made of wooden tongue depressors bound together in corset fashion with adhesive plaster is fastened about the upper arm if there is much displacement of the fragments. The arm is then fixed over the axillary pad with adhesive plaster with the forearm fixed around the base of the splint. A snug bandage which holds the arm and shaft firmly against the chest wall completes the dressing. After three weeks the union is usually strong enough to permit the arm to be released.

The *femur* is affected most frequently in obstetrical fractures. The break usually occurs in the middle third of the bone and results from obstetrical manipulation of the thigh. The accident is usually recognized immediately, but if not attention is directed to it by the marked anterior angulation that generally takes place at the site of fracture. These fractures of the femur in newborn infants are treated best by either of the following methods:

1 *Fixation in the Fetal Position*—The

thigh is usually flexed with the knee in extension thus bringing the front of the thigh against the abdomen with the front of the leg resting on the chest and the foot at the clavicle. After the skin has been powdered and a towel has been placed between the opposing skin surfaces the limb is fixed in position by a soft bandage. The dressing should be opened daily so that proper attention can be given to the skin. Fixation in this position is well tolerated by infants and tends to correct the anterior angulation.

2 *Fixation in Overhead Traction*—The child is fastened to a Bradford frame and a Buck extension apparatus is attached to both legs so that they can be held suspended at right angles to the body by overhead traction. A corset splint made of wooden tongue depressors is bound around the injured thigh and just enough weight applied so that the hips are barely lifted from the bed.

Immobilization by either of these simple methods for three weeks is usually sufficient to obtain firm union.

*Traumatic Separation of Epiphyses*—During the period of bone growth up to the age of twenty years the epiphyses may be injured.

*Etiology*—Boys in the second decade of life are affected most often probably because of the strenuous character of their exercise at that age. Constitutional diseases such as scurvy, rickets and syphilis which affect the growth cartilages may be predisposing factors, but most of the injuries occur in healthy boys. The trauma is usually a ligamentous strain caused by hyperextension or hyperflexion with abduction of the limb accompanied by torsion as when a leg is caught in a revolving wheel. The injury may occur during birth from traction on the limb with twisting. A direct blow may be the causative factor in some instances in which epiphyses such as the external condyle of the humerus or the greater trochanter of the femur are injured. In all cases the violence is of such a severe character that it would tend to produce a dislocation rather than a fracture in adult bones.

*Pathology*—The epiphyses of the long bones are involved most often especially those at the lower end of the radius the

lower end of the femur and the upper and lower ends of the humerus. The other epiphyses of the long bones are affected less often and those of the short and flat bones only occasionally. The lesion in most cases is a partial or total separation of the epiphysis from the diaphysis. An accompanying fracture of the epiphysis is very rare although it does occur occasionally at the lower end of the radius femur and humerus but the epiphyseal separation is always the principal lesion.

Epiphyseal separations may be divided into three classes according to the position of the line of separation.



Fig 414—Separation of the epiphysis of the external condyle of the humerus with periosteal stripping

1 *Division of the epiphysis* in which there is a clean separation of the epiphyseal cartilage from the diaphysis. The cartilage remains attached to the epiphysis with no osseous tissue adherent to it. This form occurs only in very young children and is rare.

2 *Juxtaepiphyseal separation* occurs when the line of separation passes through the osseous layer at the end of the diaphysis and small particles of osseous tissue remain adherent to the epiphyseal cartilage. This is a frequent form of epiphyseal separation especially in the first decade.

3 *Pre Epiphyseal Fractures*—The line of separation passes through the spongy bone of the diaphysis near the epiphyseal line and definite fragments of the diaphysis are broken off and remain adherent to the cartilage. This form occurs most often in older children in whom ossification has advanced to the extent that the epiphysis is almost united to the diaphysis.

The degree of displacement of the epiphysis depends on the direction and force of the violence and the particular epiphysis involved. *Incomplete* displacement is much more frequent than the *complete* type especially in younger children (Fig 414).

Stripping of the periosteum from the shaft usually occurs if there is much displacement as the periosteum remains attached to the epiphysis. Dislocation of an epiphysis from its joint relations is very rare but it may occur occasionally at the upper or lower end of the humerus. An accompanying injury to blood vessels and nerves may be caused by pressure or laceration from the end of the diaphysis and occurs most often in separations at the lower end of the humerus and femur. A *compound* separation of an epiphysis is a highly serious injury which often results in osteomyelitis and arrest of growth or gangrene, which may necessitate amputation.

*Symptomatology*—The clinical picture of an epiphyseal separation is more like that of a dislocation than a fracture. The injury is usually produced by a severe wrenching force. *Pain and tenderness* are most marked over the epiphyseal line. A false point of motion and deformity are evident in most cases in which there is much displacement. Discoloration from ecchymoses is usually very definite. Crepitus when it can be elicited is important because it is of a soft crunching character quite different from the hard bony crepitus of a fracture. Inability to move the limb will be present if there is much displacement. Swelling of the soft parts is usually apparent and distention of the joint is marked if the injured epiphysis is intra-articular. When the displacement is slight or partial the only evidence of injury may be localized pain and tenderness and the clinical picture will be similar to that of a sprain.

*Diagnosis*—In children and adolescents when the accident is due to a twisting force

and the clinical signs point to an injury to the end of a bone, an epiphyseal separation is probably present. A differential diagnosis should be made if possible to exclude a sprain fracture or dislocation. A roentgenogram is of considerable value except in very young children, in whom the epiphysis is not

fractures. Any displacement of the epiphysis should be accurately reduced with as little trauma as possible under the guidance of the fluoroscope, and the part should be properly immobilized. In order to preserve the function of the injury epiphysis, it is important to institute treatment at the earliest

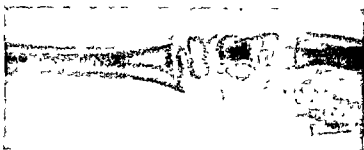


Fig. 415—Partial separation of the lower epiphysis of the radius

sufficiently ossified to cast a shadow, or in cases in which the displacement is so slight that it cannot be seen (Fig. 415).

**Prognosis**—In every case of injury to an epiphysis the prognosis should be guarded because there may be some interference with the growth of the bone. Fortunately, in most instances the epiphysis continues to function normally, especially if any displacement has been carefully reduced and proper treatment instituted promptly. However, in a certain few cases the injury will cause a premature union of the epiphysis to the shaft or interfere with the nutrition of the conjugal cartilage sufficiently to alter the normal growth of the bone.

**Arrest of growth** which may be temporary but is usually permanent will probably follow in such cases. The degree of the resulting deformity will depend on the age of the patient and the influence of the injured epiphysis in the normal growth of the bone. Injuries of the upper epiphysis of the humerus or the lower epiphysis of the radius or femur are most apt to produce growth deformities. When the growth of one of two parallel bones is affected, the normal growth in the uninjured bone will cause a marked deviation of the hand or foot. Lengthening of the bone instead of shortening may occur in rare instances when the injury exerts an irritating influence on the epiphyseal cartilage and causes an excessive growth of bone.

**Treatment**.—In general the treatment of epiphyseal separation is similar to that of

possible moment. Under general anesthesia replacement is not difficult in most cases and the parts tend to remain in position after reduction. A suitable splint which will not injure the soft parts is applied as a retention dressing. Massage and passive motion may be started after ten days. In most



Fig. 416—Old complete separation of the lower epiphysis of the femur requiring operative treatment.

cases prolonged immobilization is not required, and fixation dressings can usually be discarded after two or three weeks.

Open operation may be necessary in intra-articular epiphyses such as the head of the femur, radius or humerus to reduce the displacement and fix the epiphysis in place on the diaphysis. Operative treatment is indi-

cated also in other cases when reduction by the closed method is impossible because of muscle pull or the intervention of soft parts and in old neglected cases if the displacement has remained unreduced for several weeks (Fig 416). Interference with the circulation of the limb from injury to the blood vessels may lead to ischemic palsy or gangrene and necessitate urgent surgical treatment. Arrest of growth or excessive growth in one of two parallel bones may require resection of a portion of the shaft or excision of the cartilage of the longer bone in order to overcome the deformity.

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### COMPOUND FRACTURES

The basic principles in the management of a patient with a compound fracture are as follows:

- I Treatment of shock and hemorrhage
- II Prophylaxis and treatment of wound infection
- III Accurate reduction and complete immobilization. In actual practice these three are associated at the same time and disaster may be the result of neglect of any one of them.

**I Treatment of Shock and Hemorrhage**—Shock and hemorrhage are frequently grave and attention must be devoted to them first.

**1 Drugs**—Morphine is always indicated except in head injuries. In the instance of

multiple injuries including the brain it may still be given if accompanied by effluence.

**2 Heat**—Body temperature must be maintained in some way but this must be done with judgment and the patient not kept bathed in perspiration with loss of body fluids.

**3 Control of Bleeding**—In most instances a pressure dressing is all that is necessary. The tourniquet has been grossly misused. An ineffective tourniquet has often caused serious loss of venous blood which ceases as soon as the tourniquet is removed. Tourniquets should be of a type which can be loosened easily and definite orders should be issued as to the frequency of loosening. Usually this should be done every half hour.

**4 Traction**—The major function of traction fixation as a first aid measure before the patient is transported is to prevent or relieve shock and hemorrhage. Traction on a broken extremity relieves pain by putting muscles at rest and it diminishes extravasation by causing relaxed fascia again to exert pressures on tissues within it. Traction also limits further injury due to the churning about of fragments thereby preventing increased shock and increased hemorrhage.

**5 Fluid Replacement**—This is supremely necessary at the earliest possible moment. Loss of plasma from the blood is the early sign of shock, not a lowered systolic pressure. Whether whole blood, plasma, serum or normal saline solution is required has now been fairly well standardized by accurate laboratory tests. (See section on Shock and Collapse.)

**6 Evaluation of the Patient's Condition**—Multiple injuries are frequent in patients with compound fractures. One must try to determine immediately and without added trauma or exposure whether injuries to the brain, spine, chest, abdominal viscera and kidneys are present. Are a probable source of shock and hemorrhage require postponement of further treatment of the compound fracture or require first consideration when the patient's condition will allow of any further procedure?

**II Prophylaxis and Treatment of Wound Infection**—This should commence at the scene of accident and should be continued concurrently with the treatment of shock and hemorrhage.

1 *Dressing*—The wound should be covered if possible with a sterile dressing. The use of antiseptics irrigations etc. is not to be advised.

2 *Traction*—Traction fixation before moving the injured person from the site of accident is important in the prevention of infection. Whether the fracture is compounded from within or without the tissues are contaminated. Not to put the muscles at rest and therefore to allow the fragments to move about increases the area of contamination.

The wounds of compound fractures are of three types and in all of them traction fixation is to be employed.

Type 1 If the compound fracture is one in which there is merely a wound and if there is no known soiled bone inside the wound the traction splint will not only protect the underlying tissues but will keep the bone from coming out through the opening and getting dirty or spreading dirt around in side if such exists.

Type 2 If the compound fracture is one which has been produced by some sharp object that penetrated the extremity and if the sharp object was dirty causing contamination of the wound the application of traction will keep the contaminating organisms from being spread around underneath the skin. Everyone should insist on the application of fixed traction in either of these cases.

Type 3 If the fracture is such that the end of the bone comes out through the skin and becomes dirty a more difficult decision must be made. One fears the result of carrying soiled bone back into the soft parts as may happen under traction. This type of fracture is not common and is an injury extremely serious as regards both life and limb under any circumstances. The patient must be operated upon at the first possible moment. I believe that in order to transport the patient without danger of added trauma from the fragment of bone that remains inside the wound or without added contamination of the soft parts the use of traction is proper.

3 *Debridement*—Wounds are contaminated at first not infected and this contamination is in large part removable. With laboratory control of the requirements of

the circulatory system one does not need to wait possibly beyond the optimum time before debridement on account of shock but can treat shock or hemorrhage and debride the wound all at the same time. Without chemotherapy we set an arbitrary limit of six hours from the time of accident within which debridement may be done with expectation of success. But the danger of infection is greatly lessened if it can be done in one to two hours instead of six hours. In some instances when the injured person does not reach us until between six and twelve hours have passed debridement may still be tried although with much less hope of success for contamination will usually no longer be limited to the surface. After twelve hours debridement is contraindicated. Operative intervention then must be limited to enlarging the wound, drying open deep pockets and removing gross foreign bodies. With the use of sulfanilamide or calcium penicillin locally at the time of injury or of one of the sulfonamide drugs orally from the time of injury to the time of operation the period during which only contamination may exist and infection may not have set in has been found prolonged in many instances to seventy-two hours or more.

4 *Serums and Drugs*—Unless the injured person is known to be immunized by toxoid tetanus antitoxin should be given immediately in all cases in which there is possible clothing or soil contamination. Repeating it is to be considered if there is any further operative intervention after the first week. If the injured person is known to have been immunized by toxoid more than three months previous to injury 1 cc. of tetanus toxoid should be injected if available. Otherwise tetanus antitoxin should be administered. In severe crushing wounds in which the growth of anaerobic organisms is likely a primary dressing with zinc peroxide as recommended by Meleney is useful.

Gas gangrene serum as a prophylactic and also in treatment doses on the slightest suspicion of the presence of gas gangrene is advisable. The parenteral use of penicillin and the oral use of sulfadiazine are valuable following debridement. With limited experience thus far the local use of penicillin solution commenced with the dressing of the wound after debridement seems worth

while but the value of the sulfa drugs locally in the e cases is questionable

**5 Closure of the Wound**—No debrided wound is free from bacteria. All we can hope for is that the body resistance will cope with the remainder without the development of a purulent process. The means most likely to invoke infection is to permit tension in the wound as serum is thrown out. Therefore is a general procedure these wounds should not be sutured primarily even with a drain but left wide open. Primary suture has been successful many times but with its general use there are more instances of grave infection, osteomyelitis, amputation and death.

**6 Drainage of the Wound**—All pockets should be kept open. If their sides are allowed to fall together secretions may pocket off making ideal media for growth of bacteria. Petrolatum properly applied with or without gauze and with or without an antiseptic acts as an effective drain. It must reach every part of the depth of the wound preventing dead spaces. The wound must never be packed tightly and it should not be dressed until profuse discharge or objectionable odor makes it necessary. This saves the energy and time of the patient, the doctor and the nurse.

**7 Immobilization**—Without complete immobilization muscular action may change the site of contamination or infection at any moment. A non padded plaster encasement with or without internal fixation or two pin traction comes nearest to furnishing complete immobilization of the soft parts in order to prevent or allow infection. This does not include a window in the plaster at the site of the wound which destroys even pressure and allows edema and stasis of fluid with increased danger of infection.

**8 Treatment of Established Infection**—If emergency traction, debridement, serum and drugs, drainage of the wound and immobilization have not been adequate or successful and infection is established the principles are the same as in the care of any soft part infection early and of osteomyelitis later with this difference—in spite of treatment of the infection one must bend every effort to preserve reduction and immobilization of the fracture. The two problems cannot be separated. Whatever else is

done for gas bacillus infection adequate surgical drainage remains the important factor.

**9 Evaluation of the Wound**—In the prophylaxis and treatment of wound infection whether early or late the virulence and extent of the contamination and the severity of the soft part damage must be considered as well as the elapsed time. More contamination will usually take place in a fracture compounded from the outside than in one compounded from the inside although both unquestionably demand debridement. Major blood vessel damage may be such that the part distal to it cannot survive. The muscle damage may be such that it is evident immediately or at the time of debridement that a useful limb cannot possibly be obtained. With these factors in mind primary amputation should sometimes be done to save life or prevent prolonged morbidity, with a useless extremity as a final result.

**III Accurate Reduction and Complete Immobilization**—We have considered saving the patient from death due to shock and hemorrhage and from death or loss of limb from infection. It is necessary also to aim for proper union of the fracture at the same time.

**1 Traction**—Application of traction fixation at the site of accident makes reduction simpler in the operating room. Traction should be continued under all circumstances until the patient is on the operating table and in some form even there.

**2 X ray**—Unless hemorrhage or the time factor makes it impossible a ray examination should be carried out before debridement.

**3 Reduction**—In many instances adequate debridement will result in visualization of the line of fracture and perfect reduction can be obtained by sight rather than by palpation. Its accuracy is important as regards both infection and union. Reduction should not be delayed until infection is controlled.

**4 Maintenance of Reduction**—Complete immobilization is necessary if debridement is to be effective in preventing infection. If the fragments in an oblique fracture are slipping slightly each day the likelihood that infection will become established is increased. Unquestionably immediate rigid internal

fixation of the fragments is the best answer. Lither the Carrel technic or petrolatum gauze without closure of the wound can be used in the presence of plates and screws. Internal fixation must be rigid. The metal may be removed if infection sets in or when bony healing has progressed sufficiently. Although ideal it is questionable whether this method should be used in cases of compound fractures by surgeons inexperienced in the rigid internal fixation of simple fractures. Without this experience or in an instance in which plate screws etc. seem contraindicated the second choice is two pin traction with one (or more) pin or wire proximal and the second one distal to the fracture. Both are incorporated in the plaster of paris encasement usually after machine reduction. Again it is questionable whether this method should be used in the case of compound fractures by surgeons not experienced in the use of the apparatus in simple fractures.

Third in order of effectiveness is the non-padded plaster encasement. It presents grave dangers and offers less security but is probably safest of the three for the surgeon who treats only an occasional case.

**Skeletal traction with a distal pin only.** Russell traction in cases of fracture of the femur adhesive plaster traction padded plaster of paris encasement and splints of any material do not measure up completely to the requirements for immobilization. Conditions arise in which any one of them may have to be the method of choice in the individual case. If there is a question of adequate circulation of the part or of the thoroughness of the debridement or of the virulence of the contaminant a closed plaster encasement should not be used for several days at least but some form of traction and suspension should be used instead which allows observation of the wound and the surrounding tissues.

**5 Evaluation of the Fracture.**—In some instances it may be found that an extensive area of bone or even the entire knee joint or ankle joint has been completely blown away. Immediate amputation must be considered rather than at best a prolonged convalescence with probably a useless limb resulting.

## THE OPERATIVE TREATMENT OF FRACTURES

**Indications for Open Reduction of Fractures.**—The indications for open reduction of fractures are positive in only a few cases typically in fractures of the olecranon and of the patella with separation of the fragments. The intrusion of soft tissue between the ends of the fragments is another absolute indication for operative intervention and nerve injury complicating a fracture being treated operatively at the same time. A large proportion of other fractures should not be operated on without first trying methods of closed reduction and fixation. As a general principle if it is impossible to reduce a fracture to a place where a good functional result can be reasonably expected then it is permissible to operate. The skill and equipment of the surgeon are always a factor in the decision. In this special line of work the reports of percentages of open reductions vary from 4.5 to as high as 45.5 per cent.

Every fracture is a law unto itself and its treatment must be considered individually. Open operation should be avoided if a satisfactory functional result can be obtained without it but if it is necessary to operate the simplest possible method should be used with a minimum of foreign material. However no case should be allowed to progress to a point where callus formation has started before it is decided that open operation is necessary because the disturbance of bone-forming cells at a time when they are beginning to be active is frequently fatal to a continuation of their activity. Therefore if closed reduction will not suffice after a week or ten days of trial and if there are no contraindications such as systemic disease, circulatory disturbance or senility the operation should be performed. No fracture should be operated on if there is any active infective process in any part of the body because a blood borne infection will probably occur. No fracture should be operated on if there are abrasions on the skin which cannot be made perfectly clean and sterile. Systemic diseases which contraindicate other surgical procedures also preclude the open reduction of fractures.



**Compound fractures\*** should not be subject to open operation unless the wound is sufficiently large after debridement to allow a clear view of the fracture. It may at times be permissible to lever the bones back into position and immobilize the fracture thus rendering further manipulation unnecessary. However no foreign body of any kind—metal ivory beef bone or autogenous bone—should be introduced to maintain the fragments in position and no holes should be drilled through the bone. A fracture which is compound is always potentially infected and osteomyelitis and non union will occur if this becomes an actuality. In a large percentage of cases the first treatment of a compound fracture determines its future. The wound should be covered immediately with sterile compresses while the surrounding skin is cleansed with soap and water washing away from the edges of the wound. Then with sharp sterile instruments preferably a scalpel and a pair of tooth forceps the traumatized margins of skin should be cut off every bit of questionable muscle fascia and fat should be removed and active bleeding should be stopped. The edges of the wound should be retracted and loose pieces of bone and any debris at the bottom of the wound should be removed. It is the writer's custom then to wash the wound and the skin around it with ether which does not destroy tissue and is non irritating. When the ether has evaporated the wound is closed with through and through sutures care being taken that there is not too much tension.

Thorough debridement is the most important part of this procedure with the exception of cleansing the skin and tissues around the wound. There will always be considerable oozing from such a wound. The patient's temperature should be watched carefully, a blood count should be taken frequently and the wound should be inspected within twenty four hours by the surgeon. If infection becomes apparent the stitches should be removed and the wound opened wide for drainage. Strong antiseptics should not be used, a sharp knife does not traumatize and untraumatized tissues have marked resistance to infection whereas traumatized

tissue and blood clots offer a fertile field for bacterial growth.

**Choice of Time for Operation**—It is fairly generally agreed among surgeons that the choice of time for operative intervention in cases of fracture is from five to ten days following occurrence. This gives sufficient time for the tissues to recover from trauma and for the blood clot to organize and yet not sufficient time to allow callus to form. The swelling is less and bleeding at operation is less if this rule is followed. It also permits healing of abrasions in the neighborhood of the fracture. This does not mean however that no attempt should be made in the interim to maintain the fragments in as good position as possible. The less muscle contracture which is permitted the easier the operation and the more easily the fragments can be held in alignment after the operation.

*Fracture of the clavicle* comes to open operation less frequently than probably any other fracture of the long bones. Healing is rapid, non union is rare and a functional result is not difficult to obtain with closed methods. (See section on Fractures of the Clavicle.)

**Fracture of the Humerus**—*Fracture of the anatomical neck of the humerus* is rare indeed. It is extremely difficult to reduce and hold in reduction and in most cases this should not be attempted by closed methods. The joint should be opened and the head replaced and fixed to the shaft. It is important that the cartilaginous surface of the head is not damaged. Time then will tell whether the head will unite to the shaft or go on to progressive absorption. In the latter instance its removal will be necessary.

*Fracture Dislocation of the Head of the Humerus*—A fracture of the surgical neck complicated by dislocation of the head is practically always an operative case. No leverage can be put on the head through the shaft by the usual methods of reduction. However if the head has not protruded completely through the capsule it sometimes may be forced back by direct pressure from the anterior inferior surface. It is a difficult surgical procedure to reduce the head without damaging the cartilaginous surface and it will be found that there are usually a number of comminuted fractures

\* See also the section by Kennedy on Compound Fractures.

in the head running down toward the shaft and out toward the tuberosities the whole mass of bone being held together by the capsule of the joint. The method of fixation which is most satisfactory is to drive an ivory or bone screw from the shaft into the largest fragment of the head. The arm should then be maintained in a position of 60 degrees of abduction with the elbow on a plane with the anterior chest wall also a balanced position between extreme internal and external rotation should be sought.

*The Shaft*—Improper immobilization is perhaps the most frequent cause of non union in fractures of the humeral shaft. Operative treatment then of course is indicated. Mid shaft fractures are not infrequently associated with injury of the radial nerve and because of this open reduction is often necessary.

*Supracondylar fractures* in children are frequently confused in the mind of the student with fractures of the lower end of the humerus into the elbow joint. These fractures in children do not enter the elbow joint and in the writer's experience are practically never operative cases except as the result of malunion which should never occur because these fractures are not difficult to reduce.

Fractures of the condyles of the humerus except the internal epicondyle do involve the elbow in children as well as in adults. They should be reestablished in perfect position or if this is impossible they should be operated on and fastened in absolute anatomical alignment. It is not difficult to hold such a fracture in position with an absorbable screw or peg and this is the method of choice. Care should be taken not to damage the articular surface during operation. T or Y fractures involving both condyles are difficult to reduce by any method. Yet it is extremely important that they be reduced perfectly so that the axes of both condyles are normal. The closed method may be attempted but frequently open reduction will be found necessary. Contractures in the capsule of the elbow joint and the rapid contracture of the biceps muscle make the prognosis for a freely movable elbow unfavorable. In addition callus forms with facility and its exuberance may be the cause of a true bony block in the joint.

*Fracture of the Radius—The Head*—Frequently in fracture of the head of the radius in adults if the head is badly comminuted and displaced it should be removed being cut off at the neck so that there is no contact between the outer condyle of the humerus and the radius. In children however the head should not be removed but every effort should be made to replace the fragments in good position and maintain them so. If this is not done the growth from the proximal epiphysis will be distorted and a change in the carrying angle of the arm may occur with the possibility of loss of flexion and extension.

*The Shaft*—The radius must be considered as an extension of the hand upward just as the ulna is considered as an extension of the arm downward. The radius is concerned with motions of dexterity in the hand and the ulna with motions of strength in the elbow. Their function therefore is important and if it is impossible to reduce a fracture of the radius or the ulna or both so as to permit normal motions of the hand and elbow such fractures should undergo operative reduction. In many cases it is extremely difficult to maintain the bones of the forearm in reduction because of the cross pull of the pronators and supinators and because of the extreme activity of the muscles of the forearm. Unless proper splinting and sometimes traction are maintained after reduction angulation will take place even after open reduction in spite of firm internal fixation. This holds true in simple fractures of the radius as well as fractures of both bones of the forearm. Distal fractures in the radius are sometimes difficult to maintain in position because of the almost exactly transverse pull of the pronator quadratus which causes an angulation of the radius toward the ulna and when they cannot be maintained in reduction by closed methods they should be fastened securely by internal splinting. Fractures of the lower end of the radius into cancellous tissue are practically never operative cases because they can be molded into position better by closed methods.

It must be remembered that any shortening or deformity in the radius affects the radioulnar joint therefore it is important that the relationship between the radius and the

ulna is accurately reestablished so that no deviation in rotation of the fragments or change in their long axis is allowed as this will cause loss of dexterity in the hand

**Fracture of the Ulna**—Fractures of the olecranon if there is any separation of the fragments are always operative cases. The pull of the triceps cannot be controlled by any method other than a direct union between the triceps tendon and the lower fragment of the ulna. Therefore the upper fragment should be fastened securely to the lower fragment and in the writer's experience malleable iron wire serves as the strongest form of union. Moderate motion may be started within a few days without fear of separating the fragments.

**Fractures of the shaft of the ulna** do not present a difficult problem if the radius has not been fractured and if the head has not been removed otherwise such fractures are extremely difficult to hold in position without constant traction. The lower half of the shaft of the ulna is quite small and fragile but to it are attached strong and very active muscles. The upper half of the shaft is much stronger but not infrequently fracture of its upper third occurs in combination with a forward dislocation of the head of the radius. In such an event the radial head usually cannot be held in position without flexion of the elbow beyond a right angle and in this position it is almost impossible to hold the ulnar fracture. If this is found to be true after a conscientious trial of closed methods it will be necessary to fix the fracture of the ulna firmly by some method of internal fixation adaptable to the case—in oblique fractures a screw of absorbable material in transverse fractures some form of plate.

**Fracture of the Carpus**—The operative treatment of scaphoid fractures has been the subject of much recent discussion. Non union which is frequent leads to serious disability especially in workmen who must handle tools or bear heavy weights. Murray using a bone graft placed longitudinally through the bone has obtained better results than those reported by any other operative method. This applies particularly to fractures which occur in a single line more or less transverse through the middle third of the bone. If the fracture is comminuted removal of the bone through a posterior in-

cision with great care not to injure any of the other bones with which this one articulates gives the most satisfactory result.

**Dislocation of the lunate bone** is much more frequent than fracture. Davis favors the replacement of the bone. It is frequently impossible to reduce the dislocation by non operative methods and the operative method involves prying it back into position by instrumentation. Since it is covered on four sides by cartilage more or less damage is inflicted on the cartilage and in the writer's opinion frequently leads to the development of a traumatic arthritis. Also as the circulation to the bone is for the most part cut off by tearing of the dorsal ligament at the time of dislocation absorption is likely to occur. If replacement cannot be accomplished either by open or closed method excision is the only alternative.

Fracture of the remaining carpal bones is extremely rare and open operation in their treatment usually consists of excision. This of course is resorted to only after attempts at closed reduction have failed.

**Fracture of the Metacarpals**—It should not be necessary to operate for the primary replacement of fragments in fractures of the metacarpals and phalanges since they can be maintained in position by proper traction and splinting.

**Fracture of the Pelvis**—As a general rule fractures of the pelvis are not operative cases. Separation at the symphysis complicated by fracture of other parts of the pelvic ring however frequently requires operation because circular pressure cannot be maintained without further displacement of the other fractures. Usually they can be held by some form of suture and here again malleable iron wire has proved most satisfactory.

**General Fracture of the Acetabulum**—

**Dislocation of the Head of the Femur**—In central dislocations of the head of the femur which are the result of fracture of the acetabulum the head of the femur is sometimes driven entirely through the acetabulum and lies inside the pelvis. It is impossible to reduce this by any closed procedure and reduction by operation is extremely difficult. The approach must be from the inside of the pelvis because the fragment which lies around the base of the head of the femur and acts as a locking device prevents

the head from being moved laterally and out of the acetabulum and it must be pried back in order to permit retraction of the head. After it has been moved so that the head can be brought into normal position the fragment of the acetabulum must be forced back into as near normal position as possible in order to have a smooth socket to articulate with the head. When this is accomplished the simplest method of maintaining the head in a normal position and of preventing displacement of the fragments of the pelvis is to pass Kirschner wire or a Steinmann pin through the trochanter of the femur and to establish lateral traction which should continue until the fragments have firmly healed in place.

**Fracture of the Femur—Intracapsular Fracture of the Neck of the Femur—**There is probably no fracture in the body which results in non union so frequently as does intracapsular fracture of the neck of the femur. Indications for operation in this injury are in open dispute among authorities at present. The Whitman method of closed reduction and maintenance has been the accepted practice for many years but it has resulted in union in only 40 per cent of the cases. Murphy advocated the use of a large nail driven through the trochanter into the neck in the long axis of the neck fastening the head. Smith Petersen advocates a special nail with three flanges to maintain the head in proper apposition to the neck. Albee has advocated autogenous bone nails. The writer has used ivory screws and ivory nails of large size and while these means of internal fixation after the fracture has been properly adjusted help to maintain the desired position of the fragments they do not promote union. The lack of bony union is not entirely due to faulty alignment of the fracture but apparently is due to lack of circulation in this part of the bone. Therefore anything which has as its aim simply maintenance of position of the fragments will not promote or give assurance of assisting union. This fracture occurs usually in elderly persons and the reconstructive processes at this period of life are not so active as in younger persons. In old ununited fractures Whitman advocated removing the head removing the trochanter by an incision made from the base of the neck downward and out-

ward rounding off the upper end of the shaft and placing it in the acetabulum and reattaching the trochanter lower down on the shaft. This certainly would not be indicated in a fresh fracture. Brackett advanced the operation of rounding off the end of the trochanter hollowing out the head of the femur and placing the end of the trochanter in the hollowed out head. Neither of these operations is adaptable exactly for the repair of fresh fractures. The writer has taken certain features of both operations and designed an operation which is adaptable to fresh fractures of the neck of the femur reestablishing close contact between the shaft and the head and thereby allowing the circulation to be reestablished from the shaft to the head and maintaining anatomical relations.

**Extracapsular Fracture of the Neck of the Femur—**In the vast majority of fractures of this type it is unnecessary to consider operation. Non union seldom occurs but mal union is frequent as a result of improper reduction and immobilization.

**Intertrochanteric fractures** can practically always be reduced by closed methods and held in reduction without operative intervention. No fracture heals more kindly. It becomes united much more rapidly than does a fracture of the shaft which involves the cortical bone. However occasionally the lesser tuberosity is fractured completely free from the shaft, and it may be necessary to bring this down into position by a suture and hold it to the shaft.

**Subtrochanteric fractures** necessitate open operation when the long arm of the lower fragment which can be controlled cannot be brought into sufficiently good alignment with the upper fragment which cannot be controlled. Any internal splinting in this fracture must be firm but no matter what internal splinting device is used traction must be maintained during the period of convalescence or the great group of adductor muscles will angulate the fragment at the point of fracture and break or bend the immobilizing apparatus.

**Shaft—**Many operations which are performed for reduction of fractures of the shaft of the femur seem to the writer to be unnecessary and could be avoided if sufficient traction were applied and the pull of the muscles both as to angulation and as to

over riding were considered. The indication for operation is the impossibility of reduction by any closed method such as skeletal traction, skin traction and traction through the ligaments of the flexed joint. If operation is necessary, traction must be maintained afterward no matter what method of internal fixation may be used.

*Supracondylar fracture of the femur* should be operated on when it is impossible to reduce it by closed methods. This should include a trial with Kirschner wire through the condyles with the knee flexed at an angle of 90 degrees or more. The quadriceps bursa extends upward over the fracture and should not be entered at the time of operation but should be carefully displaced forward. The fracture if oblique may be held by a screw or nail of absorbable material which is put through at an angle so that it will not act as a pivot on which the fracture can be angulated.

*T and I fractures* and intra articular fractures of the lower end of the femur are frequently difficult to replace in anatomical position but this must be done if the function of the knee joint is to be preserved. Therefore they should be considered operative cases within the first ten days after fracture unless reduction can be accomplished by closed methods.

*Fracture of the Patella*—Fractures of the patella are always operative cases if there is any degree of separation between the fragments which indicates that the ligaments are torn. Arbitrarily one may say that any fracture in which there is more than  $\frac{1}{4}$  inch of separation is an operative case. Here again as in a fracture of the olecranon the muscles attached to the upper fragment constantly displace that fragment upward and there is no means of holding the fragments together without tying the upper fragments to the lower one. There have been many methods devised for doing this. A circular suture of chromic catgut or wire around the patella with a suture of the ligament or capsule or suturing the fragments together with silk wire or kangaroo tendon has been used. However cancellous bone does not tolerate a great deal of strain consequently there is rapid atrophy of bone or cutting out of bone cells as a result of pressure. Again the writer's preference is for

malleable iron wire because of its strength and pliability and non irritating quality. If the patellar tendon is attached firmly by strong material to the quadriceps tendon considering the patella only as an obstruction in the way of this suture much better results will be obtained than by actually suturing the bone and the fractured surfaces of the patella are absolutely in contact and are held so by the wire which passes through from the patellar tendon to the quadriceps tendon.

*Fracture of the Tibia—Intra-articular fractures of the tibia* include splints into the joint with separation of the weight bearing surface of the upper end of the tibia and bumper fractures. The latter have drawn their name from the fact that they occur when a person is struck by an automobile bumper the external condyle being driven down against the upper end of the tibia the internal lateral ligament holding the upper end of the tibia and the downward crushing throwing the knee into a valgus position. These fractures are difficult to realign by any closed method and frequently result in extremely disabling deformities. They are also difficult to operate on with the expectation of establishing complete function of the knee. The most satisfactory results have been reported by Cubbin.

The difficulty lies in the fact that there is actual crushing down and dissolution of bone cells in the upper end of the tibia on its lateral weight bearing aspect. The upper fragment must be pried loose from the lower fragment into which it is impacted and frequently comminuted it must be raised to the normal level and the interspaces filled in with bone taken from some other part of the body or from the longer fragment. It is a difficult surgical feat but the fracture should be operated on by a skillful surgeon within the first week or ten days following the accident.

*Fractures of the shaft of the tibia* usually may be reduced by closed methods if they are seen within twenty-four to forty-eight hours. The interposition of soft parts however or the catching of long oblique spikes of bone in the muscle renders it necessary to reduce them by operation. Operations on the tibia are not considered so difficult as operations on other bones because of the

superficial anterior surface which lies immediately under the skin. The surgeon must not be misled however by the ease of operation because maintenance in reduction especially in oblique fractures is not as easy as it might seem. If the fracture is oblique absorbable nails or screws may be used and the leg may be immobilized in plaster. If the fracture is transverse it is usually not necessary to operate and if in rare cases it does become necessary the abutment of the square ends against each other is sufficient to maintain alignment if dressings and immobilization are properly applied.

*Fractures of the distal end of the tibia* such as Pott's fracture usually are not operative cases. However it is advisable to fix the internal malleolus if the internal malleolus is fractured exactly on a level with the articular surface of the lower end of the tibia and it is impossible to reduce the fracture by inversion of the foot without displacing the internal malleolus toward the medial surface which would bring the articular surface of the astragalus into contact with part of the fractured surface on the lower end of the upper fragment. A single absorbable peg is driven through the tip of the malleolus into the shaft of the tibia the rest of the fibula being held in position by inversion of the foot in the usual position of reduction.

Split fractures of the lower end of the tibia occasionally occur as the result of a fall from a height one portion of the tibia being displaced forward on the astragalus and the other backward. It is necessary to bring the fragments back into position by open operation in order to reestablish the smooth weight bearing surface. If this is not exact a painful ankle joint will result. If the fragments can be wedged together and held by a screw immobilization of the ankle may be neither necessary nor advisable establishment of early motion produces a better result.

*Fracture of the posterior lip of the tibia* with backward displacement of the astragalus on the tibia is common. When manipulation will not bring this fragment down into absolutely perfect position and dorsiflexion of the foot will not maintain it in this position operative treatment is necessary. Because of its inaccessibility it is difficult to handle and the fragment of the posterior

lip is frequently comminuted and so small that no retention apparatus can be placed through it. It will be found that molding it down into shape and maintaining strong dorsiflexion will hold it in position but this flexion must not be relaxed for a moment else the fragment will slip up and the foot will have a tendency to dislocate backward on the tibia. The position must be maintained until union is complete.

*Fracture of the Os Calcis*—Fractures of the os calcis are not operative primarily. It is necessary however to cut the tendo achillis in most of these cases to prevent its effect of upward displacement on the posterior fragment of the os calcis and permit molding of the comminuted fragments and breaking up of the impaction which always occurs. Old fractures of the os calcis which result in loss of function of the joint and pain on walking are considered under the head of malunited fractures.

*Fracture of the Astragalus*—Fractures of the astragalus frequently are primarily operative if the fragments cannot be brought into anatomical position. A transverse fracture of the astragalus through the neck with the upper fragment free in the joint or displaced backward or forward must be accurately replaced if a functional joint is to be expected. If this replacement cannot be made by a closed procedure it should be done by operation but no retention apparatus should be inserted because all surfaces of this fragment are covered by cartilage except the fractured surface and a replacement with the foot held in dorsiflexion will suffice to maintain the fragments in position.

Fractures of the other tarsals metatarsals and phalanges should not be considered from an operative standpoint. It is not necessary to operate on them to obtain reduction and there have been no better results following operation than following non-operative methods.

## GENERAL CONSIDERATIONS

*Requirements of the Surgeon*.—The operative treatment of fractures should be undertaken only by a surgeon who is a mechanic and by that I mean not only the type of skilled mechanic who seals with tools but a cabinet maker who can do fine joining and carving. He must be able to do this under most trying circumstances where the parts are practically inaccessible to

instrumentation. He must have a thorough knowledge of the anatomy and physiology involved as well as the pathology. The surgical technic requires the highest degree of asepsis because bones have less resistance to infection than almost any tissue in the body, and should infection occur in a bone there ensues a long period of disability, frequently with deformity and loss of function which cannot be corrected by any form of surgery. Therefore the entire procedure of operation must be carefully planned in advance although at the same time an open mind must be maintained so that the technic can be changed if necessary, to meet the requirements of the individual case.

There can be no fixed rule for operation of any type of fracture. Since no matter how extensive an equipment the specialist may have at hand many times none of it can be made to fit or hold the fracture his mechanical ingenuity therefore must be called into play. In spite of their strength bones must be handled with as much delicacy as other tissues and most infections occur as a result of trauma to the parts during operation rather than from any other cause. The resistance of bone can be lowered by the use of crushing force as easily as that of soft tissue. Therefore the requisites of the surgeon who prepares to operate on fractures must be: First, he must be a doctor and as such considers the welfare of his patient above everything that he has a doctor's conscience and because of the dangers attendant on open reduction will not operate if less serious measures will bring about a satisfactory result. Second he must be well grounded in anatomy, in physiology and in pathology. Finally, he must be a surgeon who combines delicacy of handling of tissues with surgical judgment and mechanical skill and the ability to devise ways and means for obtaining a good result in spite of many difficulties.

**Requisites of Equipment, Operating Room and Assistants.**—Surgery of bones and joints because of its highly mechanical nature requires extensive special equipment. Fine mechanical work cannot be executed without proper tools and the man who attempts it cannot expect a satisfactory result. Motor-driven instruments are important. Facility in handling these tools can be acquired on wood and in the animal laboratory and when one is expert in their use much more skilful work can be accomplished. Further the time of operation can be reduced considerably. It is impossible to enumerate all the equipment necessary for this type of surgery but let it be said that bones vary tremendously in size and strength and the instruments used to manipulate them must also vary. The instrument used on a femur cannot be used on an ulna, because it does not fit, the instrument used on cancellous bone cannot be used on cortical bone so that a multiplicity of equipment is necessary to meet the requirements of various conditions and various bones.

The set up and personnel of the operating room is equally important. Assistants, interns and nurses must be experienced in this work and must feel that they share in the responsibility. Team work is important especially in operations involving the transplantation of bones because here two fields are prepared and movement from one to the other must take place with meticulous care. Details of operating room equipment

must be provided in advance so that there will be no possibility of contamination. It is the writer's custom to have two entirely different sets of instruments one for each field and nothing goes from one field to the other except the graft which has been removed.

The application of linen relegated by many surgeons to the intern or even to a nurse is a highly technical procedure and should not be entrusted to inexperienced hands. The surgeon should supervise the application of linen in all its phases or else do it himself having in mind the position in which he wishes to maintain the part and the position in which most of the work can be best accomplished.

**Preparation of the Patient in the Ward and in the Operating Room.**—The field or fields of operation should be prepared in the ward prior to removal of the patient to the operating room. This consists in proper shaving of the parts, cleansing with green soap and ether and the application of a large alcohol dressing. In working near the hand or foot care must be taken to shorten and clean the nails and free the interdigital spaces of any infectious material. It is the custom of some surgeons to carry out this sterile preoperative preparation two or even three times but if it has been carried out thoroughly on the day before operation once is sufficient.

When the patient is brought to the operating room the dressings are removed and again the skin is scrubbed with ether followed by iodine preferably a weak solution which serves as a guide by coloring the skin over the area to be cleansed so that no spot can be left untouched. This is followed by alcohol from 70 to 90 per cent solution in sterile water until the iodine is entirely removed. Care must be taken to see that the ether does not run up a member which is being held off the table and soak into the covering of the operating table, where it cannot evaporate readily because this may result in a painful ether burn of the skin. Sterile towels are usually tucked under the leg and into the groin or under the arm and into the axilla depending on the field of operation and are removed before the linen is applied.

**Anesthesia.**—In operations involving fractures it is usually not necessary to have such a profound state of anesthesia as in abdominal operations and the milder forms of anesthetic may be used. Nitrous oxide, ethylene or avertin may be used with success in selected cases. The most satisfactory anesthesia in the writer's opinion is avertin 70 to 80 mg per kilogram of body weight given in the patient's room. This acts as a sleep-inducing drug and nitrous oxide or ethylene is administered during the operation. This combination gives complete analgesia and is not followed by the nausea which frequently accompanies ether anesthesia. The writer has not used ether for several years in the operative treatment of fractures.

**Requisites of Ward Attendants and Postoperative Care.**—The care of fractures in the wards, operative or non-operative is fully as important as the reduction. Traction should be maintained with the amount of weight necessary to hold the fragments in position and counteract the displacing pull of the attached muscles. It should be impressed on all attendants that pain should not follow operative reduction of a fracture if properly reduced and held in proper position.

tion it is practically painless. Pain is the red flag and if a patient complains of pain following reduction of a fracture the cause should be investigated. Rather free oozing between the closing sutures is not infrequent where considerable dissecting has been necessary to free the ends of a fractured bone. This oozing from the bone cannot be stopped although active bleeding can be controlled by the use of bone wax. Almost invariably considerable bleeding is evident on the dressings. The dressings should be applied in such a way that the outer dressings can be replaced without interference with the retention apparatus and the dressings close to the wound should not be disturbed because the oozing will stop within twenty-four hours and becoming dry will seal the wound effectively.

**Methods of Internal Fixation.**—Many methods of internal fixation have been devised and advocated. As stated before one cannot be prepared to meet all the emergencies that may develop without having at hand many forms of mechanical equipment. Wire has been used since the early days of open reduction of fractures. Silver wire cannot be depended on for fixation braided or twisted phospho-bronze wire is very flexible and in a case in which little fixation is necessary may serve to steady a fracture. However if it is necessary to use wire as in fractures of the olecranon or patella malleable iron wire is most satisfactory and ordinary baling or stove wire is tolerated by the tissues as well as any other type. No metal whether it be wire or plates, will maintain a strong hold on bone for more than two weeks. No matter how tightly the metal is applied at operation subsequent bone atrophy about this foreign body will cause it to become loose.

**Steel plates** advocated by Sir Arbuthnot Lane, have been much abused by both instrument makers and surgeons. Instrument makers have made them of unreliable steel which bends easily and surgeons have used them under circumstances where they were not in keeping with the best surgical judgment. They should form a part of the armamentarium of every surgeon engaged in operative reduction of fractures but should never be used where they are in any contact with the skin and should ordinarily be buried deep under the muscles.

**Ivory plates, beef-bone plates and machined screws** are frequently applicable. The plate of ivory is set into the bone as a key in a key way and is held to each fragment by an ivory nail or peg driven through the cortex the plate having been completely drilled through from one surface of the bone to the opposite. The bone plate devised by Boughton and Eck is screwed on the surface of the bone and can be used in lieu of the Lane plate; it is also applicable in some places where an ivory plate cannot be used. Ivory or bone machined screws are useful especially in oblique fractures where several can be put in through the obliquity to join the two fragments. Both these materials are absorbable after a considerable time. Ivory is 100 per cent stronger than beef bone and will support more strain but neither ivory nor beef bone should be trusted to bridge too great a gap. They should not be set across the middle of the medullary cavity but should be placed in such a way that so

far as possible their course passes through cortical bone.

**Autogenous bone grafts** are not usually required in fresh fractures but constitute the most satisfactory means of retaining position and assisting union in ununited or malunited fractures. The difficulty of mechanically accurate application of the graft renders this a greater surgical undertaking than other methods of fixation.

**Metal Nails and Screws.**—The writer does not advocate the use of metal nails and screws but in certain cases this may be the only way to meet a mechanical as well as a surgical problem. All these methods necessitate the use of drills, taps and sometimes circular saws; therefore, mechanical skill is required in their application.

**Wedging** of the ends of the fragments sometimes is the most satisfactory method of maintaining apposition. Whether or not this can be done depends on the condition of the ends of the fractured bones. If the fracture is comminuted it cannot be done but if more or less wedged or fish-tailed at one end it is sometimes possible. Great care must be taken however to see that the line is maintained in exactly proper position after the wedging is accomplished because the assistant who holds the member by changing the position of his body, may disarrange the fragments even after the wound is closed. It is usually more satisfactory to put through a small ivory or bone screw or nail even though it be very oblique to steady the fragments and to be sure they do not slip out of position.

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#### PHYSICAL MEDICINE IN FRACTURES

The chief principles of fracture treatment, according to Wilson, are (1) restoration of anatomical form as soon as possible after injury, (2) maintenance of alignment and fixation of the fracture during the period of healing and (3) institution of measures to overcome the circulatory disturbances and to maintain and develop function beginning at the earliest possible moment after injury and continuing until complete recovery is obtained.

The intelligent use of physical therapy is not by a technician but by the surgeon; it is the only way to accomplish the third principle. To overcome the circulatory disturb-



ances heat massage and exercise are used, to develop function exercises and occupational therapy are indispensable.

Physical therapy in the treatment of fracture does not require complicated and expensive apparatus. The physical agents of the greatest use in the treatment of fractures are heat massage and exercise. Of all therapeutic adjuncts these are the simplest, the most flexible, the most easily obtainable and least expensive. Their therapeutic value is largely dependent on the skill with which they are administered.

**Heat**—Good local circulation which is essential for repair of injured tissues is increased by local application of heat. Heat should be applied for at least one-half hour three or more times daily.

To apply heat locally radiant heat from an electric lamp baker is used.<sup>1</sup> These bakers can be made by a mechanic at a cost of about \$5.00. For infra red radiation an electric room heater may be used. Radiant heat should be applied to the injured part according to definite directions from the surgeon.<sup>2</sup> One of the most valuable methods for the application of heat is the whirlpool bath.<sup>3</sup> The temperature of the bath is first 100° F. The whirling of water under pressure and the air intake make possible an increase of temperature to 115° F. This is most useful as a preparation for subsequent massage and manipulation of painful stiff joints. Its soothing warmth changes the cold purple of the swollen painful foot, leg or arm into a warm red, thereby softening the parts for massage and exercise and increasing the conductivity of the extremity for electrical treatment. The whirlpool bath is not only a thermal bath but the rapidly moving water and air bubbles give an efficient form of gentle massage. Joint motion that could not be tolerated otherwise may be given while the patient is in the bath.

**Massage**—Every surgeon should know the elementary principles of massage and should personally administer massage and motion in the early stage of fracture treatment as long as there is danger of displacement of fragments and careful management of the splints is required. In the later stages of treatment he should direct the technician definitely in the type of massage and motion required.

The following are the types of massage useful in traumatic surgery.

1 *Superficial stroking massage* consists of the passage of the hand in one direction over an area of the patient's skin with a slow, gentle and rhythmic movement. This form of massage aims only to produce a reflex effect. The pressure should be firm but gentle and light with the hand adapted to the contour of the patient's body; the muscles of the operator's hand should be relaxed. Rhythmic movements are essential to secure an even stimulus. The direction of the movement is unimportant in this form of massage provided it is always in the same direction.

Superficial stroking massage is that advocated by Mennell for the early treatment of fractures to relieve pain, secure muscular relaxation, overcome swelling and improve the circulation. For instance, on the second or third day after the reduction of a Colles fracture the dorsal splint is removed and the wrist and forearm are carefully supported on the anterior splint and placed under the electric lamp baker for one-half hour. The surgeon administers superficial stroking massage over the entire dorsal surface of the forearm, wrist and hand. The dorsal splint is then reapplied and the nurse holds the dorsal splint and the arm while the anterior splint is removed and the flexor surface of the forearm, wrist and hand is massaged by the surgeon. The splints are then reapplied. The surgeon directs the technician to give daily massage and exercise to the fingers, thumb, elbow and shoulder. At the end of a week the forearm is removed from the splints for the treatment and relaxed motion is started.

2 *Deep stroking massage* has for its aim the emptying of the veins and lymphatic vessels and the pressing of their contents in physiologic directions. It is important to have the patient's muscles relaxed or the muscle contractions will reduce the lumen of the veins and thwart the main object of this form of massage. The patient should therefore be lying down with the body completely relaxed. This position also favors the influence of gravity on the venous and lymphatic circulation. The movement should be deep and with the muscles relaxed, transmitted to all the structures under the

hand Heavy pressure is not needed as the venous pressure is slight and a heavy and irregular movement may set up a protective reflex muscular contraction which is unfavorable. The direction is always with the venous flow. The proximal segment should be treated first because if the venous and lymphatic circulation of this area is not improved that of the distal segment will be blocked.

3 *Kneading* consists in grasping lifting rolling or pressing a part of a muscle or a muscle group so as to assist venous and lymphatic circulation hasten the removal of waste products from muscles stretch retracted muscles and tendons and aid in stretching adhesions. It is used in the late treatment of fractures. The operator's hand grasps a part of the muscle (or a group of muscles) lifts it up as far as possible and kneads it. Then the same manipulations are repeated a hand's breadth farther up one or both hands being used. Where the muscles cannot be lifted as on the back the movements may consist of rolling or pressing one muscle over another.

4 *Friction* is a massage movement performed by pressing with one or two fingers or part of the hand closely applied to the skin of the part under treatment and moving it over the underlying parts. The effect of friction is to loosen adherent skin or scars free adhesions of the deeper parts such as tendons running over joints and aid in the absorption of local effusions. It is commonly used for the smaller parts such as the hand foot and face. In the later stages of fracture treatment the patient or some member of the patient's family is instructed in how to give massage treatment at home.<sup>2</sup>

*Exercise*—Early in the treatment of fracture *muscle setting* is highly beneficial and can be practiced by the patient while his leg is in the splint or cast. It consists of the alternate contraction and relaxation of muscle groups without producing motion. In a case of fracture of the leg the patient is taught to contract and relax the quadriceps muscle without movement of the knee. In cases requiring the arm to be placed in an abduction splint the patient should exercise the deltoid without shoulder movement. These exercises should be practiced under the watchful eye of the operator until the

patient has mastered them. Their importance should be stressed as they help to maintain muscle tone and prevent atrophy.

*Active exercise* the most efficient factor in the restoration of circulation and muscle strength may be performed by the patient either with or without the personal supervision of the surgeon. It may be assistive free or resistive.

*Assistive exercise* is performed with the assistance of another person or of some mechanical means. The writer uses most frequently the Grensen sling suspension method. The arm or leg which is to be exercised is supported in a sling suspended from above usually a Balkan frame. This eliminates the weight of the limb and allows the patient to translate even minimal and scarcely appreciable muscle power into active and readily demonstrable motion.

*Free exercise* follows the assistive type and is that form which is performed by the patient against the least possible resistance. The best method of obtaining free motion is by underwater exercise since the buoyancy of water eliminates the gravitational load and exercise can be carried out against the least possible resistance.

*Resistive exercise* is that form of supervised movement which offers resistance to muscle action and is intended to increase the strength of weak muscles by increasing the amount of work to be done. In prescribing exercises the writer gives definite directions and has prepared a mimeographed sheet of exercises for each joint.<sup>3</sup> For many resistive exercises an apparatus is used which can be made by a local carpenter.<sup>4</sup>

*Relaxed movement* or passive exercise is carried through by the operator without assistance or resistance by the patient. Early relaxed movement is valuable in a case of fracture involving a joint but it requires considerable skill and one must always remember that union must not be jeopardized by too early attempts at motion.<sup>5</sup>

*Graduated Muscle Contraction*—While the muscles are weak and assistive exercises are necessary painless muscle contraction by electrical muscle stimulation (faradic current) is useful in the restoration of circulation and causes physiologic contractions with all the natural changes dependent on such contractions and with the mechanical

effects due to the direct movement of the joint. The author has designed an apparatus for this purpose that can be made for about \$5.00.<sup>1</sup>

When one of the bones of the leg is fractured there is always a long period of inactivity during which the power of muscle coordination is impaired. Since all movement particularly in walking is the result of the contraction of one group of muscles combined with the relaxation of its antagonistic muscles, the efficient working of one muscle is dependent on the efficiency in many other muscles. Therefore in a case of fracture of the leg marked weakness of one group of muscles interferes greatly with proper coordination in walking at first. Too often a patient is allowed after weeks of wearing a cast to start weight bearing on his injured leg without previous exercise and even without normal support afforded his foot by a shoe. This patient gets up on crutches, his feet usually in slippers and attempts to walk with his hip rotated externally, his knee stiff and his foot everted thus causing still further muscle strain and loss of coordination.

In the proper treatment of such a case re-education in walking is essential. Again this may be made a simple inexpensive process if the active cooperation of the patient is obtained. The surgeon should supply written directions for re-education exercises in walking to be used in such cases.<sup>2</sup> The movements should be started before weight bearing is allowed and the surgeon should give instructions as to the number of times each exercise should be performed during a day. All weight bearing exercises should be performed in proper shoes with felt arch supports because the foot muscles become weakened from disuse.

**Occupational Therapy**—The prescribing of occupational therapy is based on the fact that the best type of remedial exercise is that which requires a series of specific voluntary movements which form an integral part of a more complex series of coordinated movements for the purpose of securing end products and thus furnishing direct incentive for sustained effort. The ordinary physical therapy exercises which are given to a patient last only an hour at the most and the mechanical exercises have certain definite limitations. The human body is more than a machine and the formal repetition of a movement with or without an apparatus is not of maximum therapeutic value as an exercise for there is no psychological stimulant of personal incentive which encourages a sustained effort.

Occupational therapy may be obtained in a curative workshop where there is equipment or it may be applied at home under the direction of the physician and with the help of the family. This latter choice is inexpensive and effective if the patient is willing to cooperate.

For the successful use of physical therapy in fractures it is necessary to have the physician prescribe and supervise the treatment and to enlist the full cooperation of the patient.

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## XVIII. DISLOCATIONS

### GENERAL CONSIDERATIONS

**Definitions**—A dislocation or luxation is a complete change in the relation of the articular surfaces comprising a joint. Subluxation denotes only a partial change in the relation of the articular surfaces. Total dislocation is the complete separation of a bone from its articulations at both extremities; for instance, the separation of the clavicle from the sternoclavicular and acromioclavicular joints. Traumatic dislocations may be acute, recurrent or habitual or un-reduced. Acute dislocations are caused by direct or indirect forces and rarely by unbalanced muscular action. Dislocations like fractures may be closed or simple, open or compound. The latter are more frequent in the small joints of the fingers and when present in the larger joints they are more serious as excessive direct force is required to produce them.

**Diagnosis**—The diagnosis is made from the symptoms and physical signs: (1) pain usually severe; (2) loss of function and limitation of motion; (3) alteration of contour as denoted by a change in the relation of bony landmarks; (4) palpation of the extremity of the bone in an abnormal position; (5) absence of the extremity of the bone from the normal position as denoted by a depression or lack of resistance on palpation; and (6) alteration of the length of the extremity. The roentgenograms which should be made in two dimensions or as stereoscopic films confirm the exact relation of the bones. Differentiation may usually be made from a fracture by the physical examination alone. The position and contour are distinctly different in a fracture which can usually be determined at a glance by an experienced eye. Crepitation and a point of exquisite tenderness can be elicited in a fracture and the resistance of the head of the bone can always be palpated. Errors are more frequently made in supracondylar fractures of the elbow, fractures of the neck and greater tuberosity of the humerus and fractures of the neck of the femur. Such

errors are sources of much damage as various structures are injured from repeated attempts to reduce a supposedly dislocated joint when in reality there is a fracture of the bone near the joint. Roentgenograms will of course always differentiate the two conditions.

**Complications**—Complications are quite frequent and unless recognized at once may cause permanent impairment of function or even loss of a limb. These may be enumerated as follows:

1. **Impairment of circulation**. If the arterial circulation is impaired there will be blanching of the extremity if the venous return is obstructed there will be cyanosis. Unless relief can be secured at once gangrene is imminent especially in arterial obstruction. On examination there may be obliteration of the pulse but this factor alone may often be compensated by collateral circulation. Arterial injury is most often observed in dislocation of the knee with obstruction of the popliteal artery.

2. **Nerve injury** may be due to pressure alone or to traction injury or there may be actual severance. This is more often observed in the brachial plexus in a dislocation of the shoulder, the sciatic nerve in the hip (which may rarely be caught within the joint after reduction) and the musculospiral and ulnar nerves at the elbow. Obviously reduction usually relieves pressure and function gradually returns though traumatic neuritis may persist for several years.

3. **Simple chip fractures** are frequently observed. Gross fractures are of serious consequence.

4. **Interposition of capsule, tendons, fascia or other soft tissues** may prevent reduction by any closed method. The most frequent location is in posterior dislocation of the thumb at the metacarpophalangeal joint with penetration of the head of the metacarpal bone through the capsule (so called button-holing) and between the heads of the short flexor tendons. In one instance the author found the aponeurosis of the gluteal

muscles preventing reduction of a perineal dislocation of the hip

5 Injuries to important structures such as the bladder in a dislocation of the symphysis pubis and the spinal cord in dislocations of the spine are well known and require special and immediate attention

6 Traumatic arthritis may follow, with extensive reaction within the joint as indicated by destructive and proliferative changes impairment of a nutrient artery, such as the artery of the ligamentum teres at the hip may cause sequestration and extensive destruction

7 Massive extra articular bone production caused by stripping of the periosteum may impede function or may even extend as a bridge across the joint Myositis ossificans may arise in adjacent muscles for instance in the brachialis anticus after dislocation of the elbow

8 Tenosynovitis and osteoporosis (or bone atrophy) may be serious complications especially in patients over forty years of age This is probably more frequent in a dislocation of the wrist

9 Aseptic necrosis of the femoral and humeral heads Follow up studies of traumatic dislocation of the hip have shown that aseptic necrosis of the head of the femur occurs in approximately 20 per cent of the cases This is due to traumatic injury of the femoral head resulting in disturbance in nutrition and blood supply The changes consist in increasing sclerosis and cystic changes of the femoral head frequently with gradual disintegration of a portion of the femoral head Evidences of aseptic necrosis usually appear within six to eighteen months after injury There is no method of preventing this complication although protective weight bearing for an indefinite period might lessen the possibility This is usually not practical

**Treatment**—A careful physical examination of the patient is first made including local examination with especial attention to complications A roentgenogram should be made immediately both to give a permanent record of the injury and to enable the physician to treat the injury intelligently Under no circumstances should excessive force be employed as there may be some mechanical obstruction which prevents reduction such

as an interposed ligament tendon nerve or portion of the capsule Deep anesthesia is usually required though with intelligent co-operation of the patient and with adequate analgesia the reduction may frequently be accomplished After reduction the joint should be immobilized in such a position that redislocation is impossible for a period sufficient for complete healing of the injured capsule as a rule this is about three weeks Complications are often prevented by early and gentle manual reduction When there is massive bone production as in myositis open operation is indicated but only after there has been complete organization of the new bone which usually requires from six months to one year When there is impairment of the circulation immediate reduction is absolutely necessary or there will be total loss of limb or irreparable damage Exploration is indicated in nerve injury if there are symptoms of severance or after the elapse of six weeks without improvement in function A gross fracture usually requires open reduction

WILLIS C CAMBELL

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## DISLOCATION OF THE TEMPOROMANDIBULAR JOINT

One or both temporomandibular joints may be involved double dislocation being more frequent The condyle of the mandible is nearly always displaced forward carried under the eminentia articularis into the zygomatic fossa and held there by the contraction of the temporal and masseter muscles The capsular ligament of the joint is torn Posterior dislocation is impossible unless accompanied by fracture of the tympanic plate of the temporal bone

**Etiology**—Dislocation of the jaw is caused by any force which produces an over opening of the mouth such as a blow on the chin while the mouth is open on the forcing of the mouth open during extraction of a tooth or tonsillectomy or yawning In persons with relaxed muscles and ligaments the dislocation may easily become recurrent

**Symptoms**—In double dislocation the mouth is held wide open and cannot be closed The chin is protruded Hollow spaces are felt in front of the ears where the con-

dyles ought to be The patient complains of acute pain In unilateral dislocation the chin is protruded and deflected away from the dislocated side and a hollow space can be felt in front of the ear on this side

**Treatment**—The usual method of reduction is for the surgeon to cover his thumbs with a towel and place them externally to the molar teeth on each side of the lower jaw Downward pressure is made with the thumbs the chin at the same time being lifted by the fingers placed beneath it and the condyle is thus carried under the eminentia articularis into the glenoid fossa Proper occlusion of the teeth is evidence that reduction has been accomplished General anesthesia may be necessary to produce muscular relaxation After reduction the movements of the jaw should be restricted for a week or ten days by means of a bandage or by fastening the upper and lower teeth together with wires

ROBERT H IVY

## DISLOCATION OF THE SHOULDER

Dislocation of the shoulder on account of the mechanical construction of that joint occurs frequently and is of great importance for unless after treatment is efficiently carried out recurrent or habitual dislocation is common Dislocations of the shoulder may be anterior posterior and superior Anterior dislocations are far more common and are caused by leverage of the head of the humerus against the inferior margin of the glenoid cavity in forced abduction the head is forced through the weak portion of the capsule at the anteroinferior aspect between the insertion of the long head of the triceps muscle and the subcapularis muscle After passing through the capsule the head may lodge just below the glenoid cavity—a subglenoid dislocation below the coracoid process—a subcoracoid dislocation which is far more common or rarely farther inward and below the clavicle—a subclavicular dislocation The capsule may also tear above this point on the anterior portion of the joint

There are several methods of reduction of a dislocation of the shoulder All primary or first dislocations of the shoulder should be reduced under general anesthesia and in some of the habitual dislocations which are difficult to reduce general anesthesia is also

advisable Attempts to manipulate the shoulder without anesthesia result in unnecessary trauma to the humeral head and soft structures Perhaps the most satisfactory method of reduction of a dislocation of the shoulder is by direct traction on the arm with the elbow fully extended the shoulder is gradually abducted to about 60 degrees at the same time outward pressure is exerted against the humeral head in the axilla In most instances it can be easily replaced in the glenoid fossa by this means Modification of this method has been described by Milch<sup>1</sup> With the patient supine the surgeon stands on the side of the dislocation If the dislocation is a right sided one the surgeon's hand is placed upon the patient's shoulder so that the fingers grasp the top of the shoulder firmly and the thumb is placed beneath the dislocated humeral head Thus the right hand fixes the head of the humerus as the left hand gently abducts the arm into the overhead (abducted) position Meanwhile the head of the humerus is prevented by the thumb from moving downward and as the arm is brought into complete abduction and external rotation the head of the humerus can be gently pushed over the rim of the glenoid and the dislocation reduced

Posterior and inferior dislocations require somewhat different methods of reduction A posterior dislocation is usually reduced by traction in the line of the elevated arm while an inferior dislocation is usually reduced by outward traction with pressure on the head of the humerus

After reduction a roentgenogram should be made to confirm the reduction and to rule out a fracture undiagnosed in the pre-reduction film or produced as a result of the manipulation

Another method of reduction is the Kocher method the technic of which is as follows 1 The wrist is held by one hand the elbow is flexed at right angles and the shoulder is slowly rotated outward as far as possible 2 In this position the shoulder is flexed by raising the elbow and bringing it across the chest thus approximating the head of the humerus to the rent in the capsule 3 As this movement is made the shoulder is rotated inward and reduction is accomplished usually accompanied by an audible snap There is however much difference of opin-

ion as to the rationale of the Kocher method. In many cases this method has proved difficult and somewhat unsatisfactory. It is possible that the theory underlying the Kocher maneuvers is not entirely true also it is well known that occasionally fractures of the head or neck of the humerus may be produced by this method.

**Recurrent Dislocation**—There are numerous operative procedures for repair of a recurrent or habitual dislocation of the shoulder. The most commonly used are the tenosuspension method (described by Nicola and Henderson<sup>3</sup>) and the reconstruction procedure (described by Bankart) which is based upon the premise that recurrence of the dislocation is due to avulsion

been extremely small the results show sufficient range of motion and no pain or other disability associated with this procedure. The Henderson suspension operation has extremely satisfactory results but it requires the sacrifice of the peroneus longus tendon which has some disadvantages.

**Neglected Dislocations**—In an old und reduced dislocation of the shoulder there is rapid atrophy of bone and degenerative changes occur in the articular cartilage with in thirty days the formation of scar tissue is excessive. Therefore closed reduction is contraindicated because of the danger of complicating the situation with a fracture. Operation consists of extensive exposure with removal of all scar tissue and reduc-



Fig 41 —Subglenoid dislocation of the shoulder

of the anterior portion of the capsule of the glenoid labrum from the glenoid. The Bankart procedure which consists in repair of the shoulder capsule has been employed in connection with recurrent dislocation in the present war. Recurrence of dislocation following tenosuspension methods has been reported in a sufficiently high percentage of cases in combat troops to make some other method of treatment seem advisable. So far as requirements of civilian life are concerned the Nicola and Henderson methods have been found highly satisfactory. Our experience with the Nicola operation has been sufficiently satisfactory to warrant continuation of its use as a routine procedure in all recurrent dislocations in civilian life. While our percentage of recurrent dislocations has

tion of the head of the humerus so as to obtain proper articulation with the glenoid. After three weeks gentle active and passive exercises with physical therapy are instituted. Too much force may cause an objectionable reaction. If there is extensive fibrillation of cartilage convalescence may be unduly prolonged with only partially satisfactory results. In other joints such as the elbow arthroplasty is performed at the time of reduction.

**Acromioclavicular Dislocation**—Dislocation of the acromioclavicular joint usually manifests itself as an upward displacement of the distal end of the clavicle at the acromioclavicular joint and is of relatively frequent occurrence. If the coracoclavicular ligament is not torn conservative measures

suffice as slight subluxation is consistent with good function of the shoulder. But when this ligament is ruptured as demonstrated by gross displacement permanent disability may result without open operation. Conservative measures are usually not satisfactory. Much more satisfactory results are obtained in cases of acromioclavicular dislocation if a reconstructive surgical procedure is performed immediately after dislocation rather than to wait a month or two with attempts at conservative treatment. Formation of scar tissue will produce arthritic changes in the acromioclavicular joint frequently causing continuation of disability even though the mechanical displacement is corrected. Operative repair of an acromioclavicular dislocation may be of two types: reconstruction of artificial acromioclavicular and coracoclavicular ligaments by the use of fascia lata as described by Watkins<sup>4</sup> and Bunnell<sup>5</sup> is quite satisfactory; these operations are the procedures of choice in the acute stage of dislocation. In the chronic stage of dislocation excision of the distal  $\frac{3}{4}$  inch of the clavicle has recently been advocated by Gurd<sup>6</sup> and Mumford<sup>7</sup> and has given excellent results.

**Sternoclavicular Dislocation**—Sternoclavicular dislocation is much less common and consists of upward and anterior displacement of the medial extremity of the clavicle. Reduction is easily accomplished by direct pressure on the clavicle but it is impossible to maintain the reduction by any type of external immobilization or fixation. If the dislocation is of sufficient extent to produce disability or deformity surgical repair of the supporting structures of the inner end of the clavicle is necessary. Repair of the capsule of the sternoclavicular joint with wires or fascia across the joint between the clavicle and sternum is usually inadequate and recurrence of dislocation is common following such a reparative procedure. Perhaps the best method of repair of this dislocation is by using a strip of fascia lata passed through or around the end of the clavicle just lateral to the sternoclavicular joint and passing around or under the first rib. The capsule can then be repaired in the usual manner. The results of the operation have been good. Excellent function is possible without reduction.

**Dislocation of the Sternum**—Dislocation of the sternum is rare the most frequent form being dislocation of the manubrium forward or backward on the gladiolus. Reduction may be accomplished by inserting a corkscrew into the manubrium for traction with a periosteal elevator the fragments are levered into normal relations.

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#### DISLOCATION OF THE SPINE

Dislocations of vertebrae without demonstrable fracture occur for the most part in the cervical spine. Approximately 50 per cent are of the atlas on the axis because of the shallow facets, their nearly horizontal surfaces and the normally wide range of motion between them. They are caused by falls, diving accidents or such a trivial trauma as unguarded throwing of the head about to look over the shoulder.<sup>1,2</sup> Non-traumatic dislocations have occurred during the course of an infection of the respiratory tract.<sup>3</sup> Destructive lesions of Pott's disease and of osteoarthritis may produce secondary luxations.

The usual type of dislocation is unilateral, one lateral mass rotating anteriorly until its articular process slips beyond the underlying facet and falls into the intervertebral



notch. Here it is locked against the anterior face of the superior articular process of the underlying vertebra (Fig 418 *a*). With incomplete rotary subluxation the articular process catches on the facet of the next lower vertebra before jumping the crest (Fig 418 *b*). With bilateral dislocation if complete the body slides forward and upward on each side until the processes drop into the intervertebral notches. With incomplete dislocation the body slips forward until the articular processes catch on the surfaces of the underlying facets. The subluxation is then maintained by the weight of the head. Posterior dislocation of a cervical vertebra is unusual. It must of necessity be

time and eliminates the useless application of a cast in a case of unreduced dislocation.

Clinical examination reveals malalignment and restricted movements. In bilateral displacements the head is carried forward with the chin at a normal level or acutely flexed on the chest depending on the completeness of the dislocation. In unilateral luxation there is a wryneck with the chin turned away from the side on which the dislocation is located. If the articular process has dropped into the intervertebral notch the head is laterally flexed toward the shoulder of the same side. If the articular process is caught on the crest of the facet the head will be laterally flexed away from the side



Fig 418—Accurately retouched x rays of rotary dislocations of the neck, both of which were successfully reduced later. *a*, Articular process of the fifth vertebra locked in the intervertebral notch of the sixth vertebra. *b*, Articular process of the fifth vertebra caught on the crest of the underlying facet of the sixth vertebra.

accompanied by laceration of the interarticular ligaments or fracture of the pedicles of the vertebra above and the manipulation must be planned accordingly.

**Diagnosis**—Routine x ray pictures are fully taken and interpreted will show the dislocation in the majority of cases. Additional oblique or posterolateral views may be necessary to show facets and processes. The laminagraph<sup>7, 8</sup> has added much to the accuracy of diagnosis in the difficult region of the upper three cervical vertebrae. In certain milder subluxations or vertebral locks the surgeon must rely on the physical findings and the history despite inconclusive x ray films. Fluoroscopic control during reduction of a severe dislocation saves

of injury. Rotation of the head is possible away from the dislocation but stops short when an effort is made to turn toward the luxation. Discomfort is present but is not necessarily severe.

Transection of the spinal cord or any lesser degree of damage to the cord or spinal nerves may result. Such damages even complete paraplegia may be due to edema or hemorrhage rather than laceration and necessitate prompt reduction. Neurological findings are scant in some cases. However sudden death has followed an inadvertent movement days or weeks later in unreduced cases even when the case had been neurologically symptomless.

**Treatment**—Closed reduction is the

method of choice. The consensus of modern opinion is that laminectomy is rarely if ever indicated as the treatment for displacement or the accompanying nerve injuries.<sup>1, 2</sup> At best open operation relieves only the posterior pressure while anterior angling of the cord continues. After reduction if pressure on the cord persists laminectomy should be considered. For closed reduction the operator must have a vivid mental picture of the exact pathologic condition present and the change with each successive step of the manipulation. Reproducing the displacement on an articulated skeleton greatly helps visualization of the problem and its solution. If reduction is not complete a second effort or even repeated manipulations may be required.

Walton's<sup>11</sup> method is especially applicable to unilateral dislocations. The operator stands at the head of the table supporting the patient's head and neck as they are drawn beyond the end of the table. One hand is placed alongside the head on the displaced side. The other hand is cupped under the chin from the opposite side. The chin is rotated away from the dislocation unloading it. The heel of the cupped hand is used as a fulcrum while the head is next laterally flexed away from the dislocation until the articular process is lifted above the bony block. With lateral flexion still maintained the head is slowly and firmly rotated back toward the dislocation and beyond normal range until full correction has been secured. Usually a definite click is palpable and audible as the process clears the obstruction. The head is then hyperextended and lateral flexion released.

Taylor's<sup>10</sup> technique is safer for a bilateral displacement and in a case in which fracture complications are suspected. The head sling on the patient is attached to a belt about the operator's waist for traction. Counter traction is secured by shoulder straps on the patient held by assistants. Traction is maintained for five or ten minutes until the neck muscles have relaxed and the articular processes have been lifted from the lock. The neck is then hyperextended over the end of the table while the operator uses his hands to maneuver the vertebrae into line. Traction may be continued during the application of the cast if indicated.

After reduction the neck must be kept in hyperextension so that the articular processes will be thoroughly seated in proper position during healing of the damaged joint capsules. Redislocation easily occurs if the patient drops his chin before the repair has been completed or if the lacerated posterior ligaments have been distracted by prolonged traction.<sup>4</sup> The most effective immobilization is a plaster of paris corset from the top of the head to the lower rib margin. Skeletal traction by tongs or wire through the outer table of the skull is reserved for cases complicated by fractures of the jaw or extensive head injuries.<sup>3</sup> Severe dislocations and those complicated by a lapse of time require the wearing of a plaster corset for at least six weeks. It may then be replaced by a celluloid collar to be worn over a period varying from three months to a year. A collar has the advantage of being removable for physical therapy. In very mild subluxations a Thomas collar worn for three weeks will give adequate protection from unexpected jars and will hold the chin sufficiently high. Should a dislocation recur several times despite complete reduction and prolonged immobilization some form of operative fixation will be required.<sup>7</sup>

In some recent cases reduction may be obtained without anesthesia. In all others general anesthesia results in a better reduction either being used when full relaxation is desired. With the patient under full anesthesia a dislocation of many months standing has been successfully reduced by closed manipulation.<sup>1</sup>

Actual dislocations of the thorax and lumbar spine occur as the result of severe fractures. Subluxations or disalignments in the lumbosacral and sacroiliac articulations constitute a large and important field for careful consideration. (See the chapter on Painful Affections of the Lower Back.)

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## DISLOCATION AT THE ELBOW

**Anatomical Considerations**—The bony prominences at the elbow are the olecranon the two epicondyles the supracondylar ridges the head of the radius the lower portion of the humerus anteriorly and the coronoid process of the ulna felt in front of the joint (Chiene). The olecranon projects posteriorly and is felt plainly except in extreme extension of the arm. The trochlear surface has a downward and inward inclination which makes its outer portion higher than its inner one. The radiohumeral joint, on the other hand presents a horizontal line. These two facts tend to explain the greater prevalence of external lateral dislocation over internal lateral ones. From the obliquity of the joint surfaces is produced the "carrying angle." In semiflexion the external condyle is easily seen in acute flexion the radial head hides it. The relation of the bony points is shown in figure 419. In children and in many women and some men, the elbow joint permits the forearm to be extended beyond the straight line of the humerus on account of the relatively small beak of the olecranon. This is one reason why posterior dislocation here is more common in women and children. The elbow is a true hinge joint and owes its strength mainly to its bony conformation.

**Types and Frequency**—In the order of frequency elbow dislocations follow those of the shoulder and the fingers. They are commonest in males about four to one. In children the condition is much more common than is dislocation of the shoulder. The different forms of dislocation are numerous for the two bones of the forearm may be displaced together in any one of the four principal directions or each may take a different direction or either may be dislocated while the other remains in place. The number of forms is further increased when distinction

is made between complete and incomplete degrees. Owing to limited space, only the more common varieties will be discussed in detail.

**Posterior dislocation**, the forearm bones being displaced backward at the elbow, is the commonest dislocation in this region (Fig 420).

**Etiology**—The usual cause is a fall on the outstretched hand with the elbow in extension and the limb in semiabduction. The

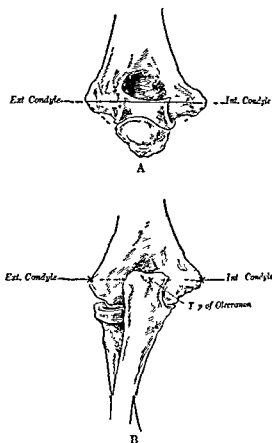


Fig 419—Posterior views of the bones of the elbow joint. *A* In right angled flexion. *B* In full normal extension. Note that in extension the tip of the olecranon approaches the internal condyle.

luxation is caused at times when the arm is forced forward and the forearm forced backward as may occur in football and wrestling or when the arm is caught between two objects moving in opposite directions.

**Symptoms**—There is marked deformity. The olecranon is more prominent posteriorly. The coronoid process and the head of the radius lie posterior to the humeral

\* Flason. Fractures of the Humerus Radius and Ulna, D. Appleton-Century Co., Publishers

articulation. The joint is held in rigid semi flexion, the forearm is usually pronated and appears shorter than normal an impression due to the fullness in the antecubital space. The forearm cannot be completely flexed. The normal interrelation of the elbow triangle is lost the lines between the olecranon and the condyles and between the condyles is destroyed. In thin persons seen soon after the injury, a decided hollow is noted on each side of the triceps tendon. In addition to a laceration of the ligaments there is laceration of the brachialis anticus muscle which is often stripped up from the anterior surface of the humerus as well as from the coronoid and the shaft of the ulna sometimes with associated fracture of this process

other epicondyle is intact with the humerus and the other moves with the forearm.

*Treatment*—Reduction is extremely simple in early cases. If the patient is seen within a few seconds or moments after the dislocation simply making traction on the forearm results in reposition. If the patient is a child place him supine on a table flex the arm to the vertical position grasp the lower end of the humerus with interlocked fingers anteriorly and with the thumbs placed against the prominent olecranon push forward letting the forearm fall forward into the flexed position. The more usual method is moderate extension downward and traction on the forearm with counter traction on the arm in a backward direction. This is

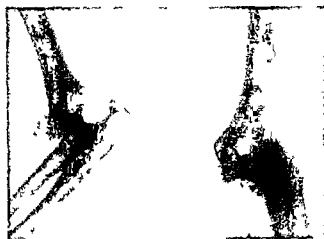


Fig 120.—Posterior dislocation of the radius and ulna. Note also the external lateral displacement, which nearly always exists.

After seven days the dressing is removed and gentle restricted passive motion or preferably active motion through from 15 to 25 degrees is indulged in every second day. At the end of four weeks during which time the elbow has been gradually brought to a right angle all restraint is removed and light stretching and flexion are performed.

The *prognosis* is favorable in children and usually also in adults. Complete extension is the last motion to be perfected. Often months will elapse before the joint will extend completely. One must have patience and not force matters.

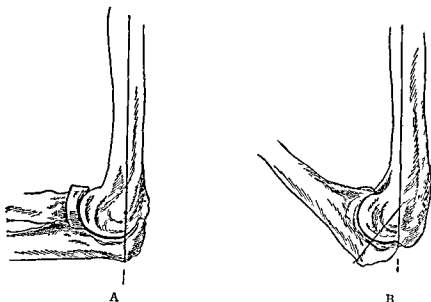


Fig 491.—Diagram showing the relation of the bony parts of the elbow in (A) right-angled position (B) acutely flexed position. Note the relative position of the condyle and the tip of the olecranon in each.

A very distressing and not uncommon complication or sequela is myositis ossificans or ossifying hematoma which occurs in the antecubital space and frequently causes a much crippled elbow.

**Lateral dislocation** in the majority of cases is backward as well as lateral. The outward variety is the more common and is usually incomplete and associated with a sprain fracture of the external epicondyle (Fig 490).

**Etiology**—Lateral dislocation of both bones of the forearm usually follows a fall on the hand while the arm is extended. It may be due also to forcible abduction or adduction of the forearm.

**Symptoms**—In complete dislocations the forearm parallels the humerus but being displaced externally the forearm bones are posterior and lateral to the articular surface of the humerus. In external lateral dislocation the internal condyle is prominent and the forearm is usually pronated. In internal lateral displacement the forearm is usually supinated and the external condyle is most prominent. The usual pain, swelling, rigidity and loss of function result. The displacement is usually incomplete.

**Treatment**—Reduction by direct traction on the forearm with lateral finger and thumb pressure and manipulation is successful. This

dislocation if associated with fracture as is usually the case easily results in recurrence.

**Forward dislocation** rarely occurs and is almost invariably associated with fracture of the olecranon or fracture of the humerus which permits the forward displacement. It is almost always due to a fall on the flexed elbow.

**Symptoms**—The elbow usually swells rapidly and extensively. The humerus can be felt posteriorly except when the olecranon is fractured.

**Treatment**—Reduction is accomplished by traction on the forearm in the line of its

\* *Flayson* Fractures of the Humerus Radius and Ulna D. Appleton-Century Co. Publishers

deformity together with pressure backward in the antecubital fossa. When the condition is associated with fracture of the olecranon fixation in the extended position is necessary for approximation of the fragments or open reduction for the same reason.

The prognosis of obtaining a well functioning joint should be very guarded for this fracture dislocation occurs in adults.

**Divergent Dislocation.**—There are two types of divergent dislocation of the bones of the forearm: (a) anteroposterior in which the ulna passes up and behind and the radius in front of the humerus and of which few cases are reported; (b) the transverse type in which the radius passes to the outer and the ulna to the inner side of the humerus. The cause is a fall on the outstretched hand with the elbow in extreme extension. Reduction is accomplished by traction and manipulation in hyperextension replacing the ulna first; the radius is then easily adjusted by finger pressure. The prognosis is guarded depending on the severity of the causative trauma.

**Dislocation of the ulna** occurs rarely. Cases representing three types have been reported: forward, backward and inward. Backward dislocation is the most frequent and is usually incomplete. A cubitus varus exists. The radius is in place, the olecranon is posterior and prominent and the forearm is in the pronated position. Reduction is accomplished by overextension and traction. Fixation in the acute position is the treatment of choice.

**Dislocation of the radius** is not an infrequent condition but is usually associated with a fracture of the upper third of the ulna. The dislocation is anterior in the majority of cases but it may be lateral or backward. The injury is usually the result of a fall or heavy blow on the ulnar side of the forearm in pronation.

**Symptoms.**—The head of the radius is usually felt anterior and somewhat mesial to its usual position. There is a depression beneath the lateral radial dimple below the capitellum. If the dislocation is of the posterior type the head is felt posterior and the forearm is deflected to the radial side and pronated. A cubitus valgus is present. In the anterior dislocation the forearm is slightly flexed but this flexion cannot be

augmented beyond a right angle. All motions are painful and limited. In old cases the displacement may be very pronounced.

**Treatment.**—Reduction is best accomplished with the forearm partially flexed by traction and rotation at the same time making outward and backward pressure against the head. Reposition offers no difficulties in the absence of fractures of the head itself. Maintaining the reduction is difficult at times especially when there is a complicating fracture. Dressing on an internal or preferably a Gutter splint usually suffices. If these measures fail fixation in acute flexion is indicated.

In children the condition not infrequently is unrecognized. In young children from four to six years of age a subluxation or pulled elbow occurs (Malgaigne's subluxation). The usual history is that the child was lifted or jerked by the hand to prevent its falling in going up a stairway or attempting to step up on a curb. The child will not use the arm and it hangs from the shoulder in slight adduction and internal rotation. All motion of the forearm especially supination is resisted. There is tenderness and often a slight depression may be observed over the head of the radius. Reduction is easily obtained by supination and outward pressure on the subluxated head. A sharp click announces the reposition. The child will then use the arm freely. With the possible exception of a sling for a day or so no dressing is necessary. The results are excellent. If the condition is unrecognized the child will frequently have a good elbow but with a very movable radius at the elbow.

**Dislocation of the Radius with Ulnar Fracture.**—The writers have collected reports of forty-four fractures of the upper third of the ulna. In eight of these the radius was dislocated in seven anteriorly. This combined injury usually results from direct violence such as a blow on the ulnar side of the forearm, a fall or more commonly a blow on the forearm flexed and raised over the head to protect it from injury. It is called a *parry fracture* (Fig. 422). The diagnosis is easily made.

**Treatment.**—The dislocation should be reduced first by traction, rotation and outward pressure on the head. After reduction of the radius if the fracture of the ulna is

still unreduced, the forearm is flexed and externally rotated. This uses the radius as a lever against the humerus and with traction tends to reduce the ulnar fragments. If this position results in a redislocation, as it often does, a trial may be made with the forearm fixed at a right angle at the elbow. If this fails, it has been found that traction in the extended position on a Thomas arm splint for two weeks frequently maintains the two

or non-union or viscous union of the ulna in a bowed position often occurs.

**After-Treatment**—In all uncomplicated luxations of the elbow, rest but not absolute fixation should be maintained for from two to three weeks, depending on the age of the patient. Fixation for a period of ten days in the right angled (rarely acute angled) position is indicated, together with a few degrees of motion after the ten days. After two to three weeks no dressing is used, unless possibly a sling is needed to prevent overextension.

In luxation of the elbow in youth the prognosis is favorable, but it must be guarded in older patients. Loss of motion, especially in flexion, is sometimes encountered. Myositis ossificans and ischemic muscular atrophy are occasional complications. Nerve injuries occur uncommonly.

**"Old Dislocations."**—In view of the statement made elsewhere that a dislocation of the elbow "grows old" early, frequently in ten days in children and two weeks in adults, it behooves the surgeon to x-ray all injured elbows in order to prevent an oversight, for, as a rule, an old dislocation of the elbow cannot be reduced by closed manipulation after the period mentioned. The pathologic condition is changed by the development of ossifying hematoma and connective tissue deposit filling the joint spaces, plus bone fragments. These prevent reposition. In such cases arthrotomy must be performed as soon as the condition is recognized. In youth the result is usually good, but in adults functional results are much less favorable.

**Congenital dislocations**, according to Stimson, are rare, and many of the cases reported could well have occurred after birth, even though several were bilateral in character. Those associated with the absence of parts of the ulna or deficiency of the elbow joint might well be congenital. Operative treatment is usually indicated.

**Pathologic Dislocations.**—A very few "pathologic dislocations" have been reported. The condition is so rare and so easily diagnosed and treatment so unsatisfactory that consideration of the lesion is unnecessary here.

ELDRIDGE L. ELIASON.  
JULIAN JOHNSON.



Fig. 122.—Fracture of the upper third of the shaft of the ulna together with anterior dislocation of the head of the radius.\*

reductions. Some surgeons treat these cases in acute flexion after reduction. If reduction of either is lost, an open operation on the ulna should be performed. The after-care is maintained for two weeks, during which time only slight rotation is performed. The limb is treated as in cases of fracture.

**Prognosis.**—The prognosis is only guardedly favorable, as subluxation of the radius

\* Eliason. *Fractures of the Humerus, Radius and Ulna*, D. Appleton-Century Co. Publishers.

## DISLOCATIONS OF THE CARPALS, PHALANGES, PELVIS, COCCYX, HIP, KNEE AND ANKLE

**Dislocations of the Carpals**—There are three common types of dislocations of the carpals all associated with dislocation of the semilunar bone (1) dislocations of the semilunar bone forward (2) dislocations of the semilunar bone forward with fracture of the carpal scaphoid and (3) dislocation of the second row of carpal bones backward upon the semilunar bone (transcarpal dislocations)

lack of motion stiffness much limitation of use of the fingers and considerable pain are noted Sometimes pressure of the semilunar bone on the median nerve results in tingling and numbness over its distribution in the hand

**Diagnosis**—The following findings establish the diagnosis a swollen wrist twice the anteroposterior thickness a prominence on the front of the wrist a diminution of all motion and pain on effort to move the wrist Roentgenograms in the lateral view show forward displacement of the semilunar bone with the articulating cup pointing forward

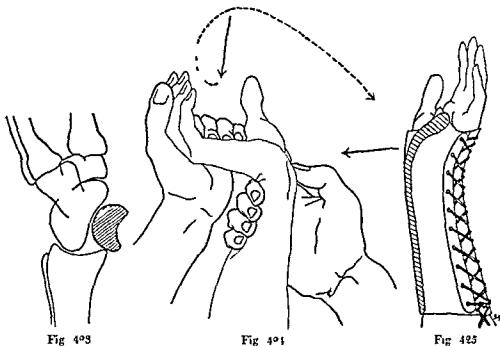


Fig 420

Fig 421

Fig 422

Fig 420—Lateral view of an anterior dislocation of the semilunar bone

Fig 421—Method of reducing an anterior dislocation of the semilunar bone by hyperextension of the hand

Fig 422—Leather wristlet for support of the wrist during convalescence

**Etiology**—A great majority of these injuries are the result of a fall on the extended hand. The hand is pushed violently backward and the semilunar bone pops forward. When the hand is then returned to its normal position the semilunar bone remains forward out of place the distal articular surface facing forward or the semilunar remains in the normal position and the os magnum is displaced dorsal to it. Usually there is fracture of the scaphoid.

**Symptoms**—The patient believes he has only a sprained wrist and may continue to work for hours or even for days. Swelling

(Fig 423) In type 3 the os magnum is dorsal to the semilunar which has remained in normal relation to the lower end of the radius. Roentgenograms made of the normal wrist in two positions are very helpful.

**Treatment**—Reduction is necessary even if the dislocation has been unrecognized for days. The writer has successfully reduced a fracture that was four weeks old.

Under complete anesthesia with the traction to the hand the wrist is bent backward hyperextended so that the opening through which the semilunar was displaced is reopened and the semilunar bone is then



pushed from the front backward into its normal position between the radius and os magnum (Fig 424) Reduction is a matter

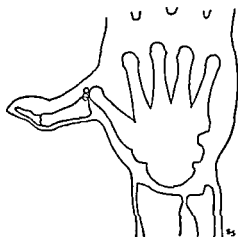


Fig 426—Metacarpophalangeal dislocation of the thumb

of pull push and bend The results of the reduction are then checked by roentgenograms A compression bandage is applied to

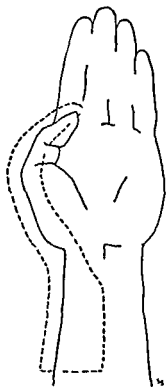


Fig 427—Position for fixation of a dislocation of the metacarpal with a molded plaster splint

allow the swelling or an anteroposterior plaster is molded to the wrist

Other dislocations of the carpal are treated by similar maneuvers After ten days

or two weeks of rest, active motion may be begun supplemented by massage If there are associated fractures particularly of the scaphoid longer fixation (ten to twelve weeks) is desirable A leather wristlet (steel reinforced) holding the wrist in subdorsal flexion may be useful in returning the patient to work (Fig 428) If reduction fails an open operation may reduce the dislocated bone by leverage Rarely is removal of the bone necessary Results obtained at the Massachusetts General Hospital

#### 1 Dislocation of the semilunar bone forward

Treated by manipulation

Good economic functional and anatomical results

#### 2 Dislocation of the semilunar bone and fracture of the scaphoid

Treated by manipulation

Prolonged fixation (twelve weeks)

Good results

#### 3 Unrecognized dislocation of the semilunar bone and fracture of the scaphoid

Two operations on one man

Bad results Stiff and painful wrist

**Dislocations of the Metacarpophalangeal Joint**—Dislocation of the metacarpophalangeal joint of the thumb is the most common dislocation (Fig 426)

**Etiology**—Forcible hyperextension of the thumb causes the dislocation

**Pathology**—Laceration of the joint capsule usually anteriorly occurs The projecting metacarpal head becomes entangled with the long flexor tendon or between the two heads of the flexor brevis pollicis

**Symptoms**—There is deformity of the finger with the proximal phalanx displaced backward and lack of function

**Treatment**—The thumb is hyperextended and the base of the phalanx is pulled upward and forward and rocked from side to side to disengage the tendons which are locked about the neck of the metacarpal bone Traction is of no value as it tightens the grasp of the tendons about the metacarpal head After reduction a plaster of paris splint is put on the thumb in the flexed position (Fig 427) it should be extended from the wrist to the tip of the thumb nail (position of grasp) Active motion may be begun after one week If reduction is im-

possible open operation must be carried out. The joint capsule is opened through a posterior incision and the tendons are pushed aside from the neck of the metacarpal bone.

Similar dislocations may occur in the metacarpophalangeal joint of the middle and little fingers. Difficulties may be encountered in a like manner in reduction and here again surgical operation may be necessary. Open reduction should be carried out as soon as the hand can be properly prepared for incision since delay results in a stiff joint.

Results obtained at Massachusetts General Hospital

1 Immediate reduction (closed or open)

Good results

2 Delayed open reduction (closed impossible)

Bad anatomical result poor functional result (stiff joint)

**Dislocations of the Phalanges**—The various phalanges of the hand may be dislocated in any direction but usually the dislocation is forward or backward. It is often complicated by a small chip fracture. The dislocation is easily reduced under local block anesthesia and the finger held in place by a simple splint or by traction.

Luxation of the distal joint is common. This is usually associated with a drop of the distal phalanx and is called a baseball finger. In baseball finger there is a rupture of the distal portion of the extensor tendon. The finger may be splinted in hyperextension for six weeks. (See section on Rupture of Tendons.)

Dislocations of the phalanges of the foot occur frequently and are usually associated with much swelling of the joint. They are easily reduced and held in place with a simple molded plaster splint or adhesive strap ping.

**Pathology**—An evulsion of the extensor tendon from the back of the terminal phalanx.

**Treatment**—An anterior splint is maintained for from four to six weeks. If it is applied immediately it is usually effective. If not the result is a dropped finger and failure of the voluntary extension of the distal phalanx. Late efforts to correct this deformity by splint or surgical operation usually fail.

**Dislocations of the Pelvis**—These are very rare except when associated with fracture and either follow severe falls or are associated with childbirth. (See section on Fractures of the Pelvis.)

**Pathology**—The dislocation is caused by the tearing of the ligaments at the symphysis pubis with relaxation of the ligaments of the sacrospinous joint.

**Symptoms**—Pain is felt on walking on motion of the pelvis and on extreme flexing of the thigh. Separation of the symphysis is palpable.

**Diagnosis**—A diagnosis is easily made. Roentgenograms show the separation and rising up of one pubic bone from its fellow.

**Prognosis** depends on the extent of the injury to the contents of the pelvis that is the bladder, ureters and sometimes the rectum. The results in a case of simple dislocation are good.

**Treatment**—The intra-abdominal injury requires rest in bed and fixation of the pelvis with a pelvic belt until the ligaments are healed. Sometimes traction on the leg with adhesive plaster is necessary to bring the symphysis into alignment. The patient usually can walk after from ten to twelve weeks. In cases of severe dislocation of the pelvis skeletal traction is necessary for reduction.

**Intrapelvic Dislocations** (See section on Fractures of the Pelvis)—Intrapelvic dislocations of the head of the femur with fracture of the acetabulum follow severe falls directly on the hip. The head of the femur is driven through the acetabulum and impacted in the pelvis.

**Pathology**—The fractured acetabulum opens and permits the passage of the femoral head into the pelvis.

**Symptoms**—There is little motion of the hip and relatively little pain. The leg measures about 1½ inches shorter than the other leg. Palpation of the hip shows a depression in the region of the great trochanter.

**Treatment**—It is often difficult to extract the head from the pelvis but it can usually be accomplished by gentle prolonged manipulation. Traction with the leg in extreme abduction will effect reduction in some cases. Thereafter the leg must be kept in extreme abduction to prevent recurrence of the dislocation until a new acetabular cavity reforms. Usually there is some redislocation.

of the head because the new socket is not strong. However the end result is economically good but only fair functionally and poor anatomically.

Recently there has been some operative work done on the pelvis in an effort to restore the fractured acetabulum—acetabuloplasty but the results have not been satisfactory.

**Dislocations of the Coccyx**—These injuries are most common in women and may follow passage of the infant's head during childbirth or sometimes follow direct blows over the coccyx. Clinically displacements of the coccyx are anatomical variations or are associated with fracture. A true dislocation is rarely seen.

**Pathology**—Displacement of the coccyx is usually upward.

**Symptoms**—A great deal of local pain and discomfort results and unfortunately no method of treatment and no position gives any considerable relief. The patient seems to suffer considerable pain at all times except when standing up or sitting up on a high stool.

**Diagnosis**—When an examination of the rectum is made with the finger, the dislocation can be palpated. Roentgenographic diagnosis is difficult because of the numerous anatomical variations found.

**Treatment**—A true dislocation can be reduced by the finger in the rectum. Rarely is surgical intervention necessary.

**Dislocations of the Hip**—The hip joint is strong and has a wide range of motion. The head projects into a deep acetabulum and is held in place by strong ligaments the strongest being the anterior Y shaped ligament of Bigelow. The muscles about the hip are powerful. The landmarks are the great trochanter, the anterior superior spine, the tuberosity of the ischium and the head of the femur. Dislocation of the hip is usually an injury of a middle aged person and is five times more frequent in males than in females. In children the epiphysis is separated, in elderly persons the neck of the femur is fractured.

**Etiology**—Dislocations of the hip result from falls or injuries which occur when the thigh is flexed. The injury is uncommon but crippling if not recognized.

**Pathology**—The head of the femur is

twisted out of the acetabulum and the interior part of the capsule is torn. The head leaves the joint through this tear the Y shaped ligament of Bigelow acting as a fulcrum and comes to rest either in back (posterior dislocation) or in front (anterior) of the joint—rarely above or below (Fig. 428).

**POSTERIOR DISLOCATIONS**—**Symptoms**—The thigh is adducted and internally rotated, the knee is bent so that the inside of the foot rests on the opposite instep. The great trochanter is pushed upward. The head of the femur can sometimes be palpated in back of the great trochanter and moves with it. There is little motion of the hip. The patient is unable to stand on the

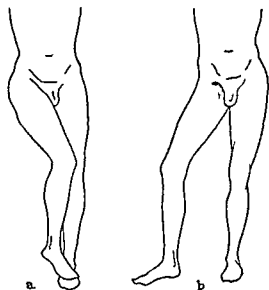


Fig. 428—*a* Posterior dislocation of the hip *b* anterior dislocation of the hip

leg. Roentgenographic examination shows that the head of the femur is out of the acetabulum. There is apparent shortening. The sciatic nerve may be injured when an effort is being made to reduce the dislocation.

**Treatment**—Allis method. The patient under complete anesthesia lies on the floor. The dislocation is reduced by reversing the path of dislocation using the Y shaped ligament of Bigelow as a fulcrum. The ankle is grasped in one hand, the other hand is clenched, the forearm is placed under the patient's flexed knee and the thigh is flexed (Fig. 429). This brings the head of the femur down. A motion is made as though lifting the patient from the floor. This brings

the head to the edge of the acetabulum. The leg is then rotated inward, lifted again and

The rotation clears the head of the capsule, muscle, vessels and nerves



Fig 429—Showing the grip used in the reduction of a dislocated hip

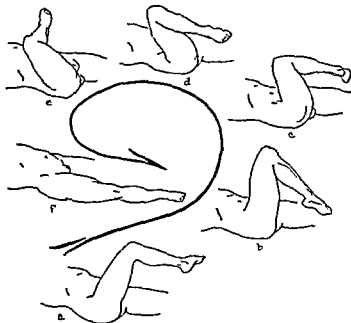


Fig 430—Bigelow method of reduction of a posterior dislocation of the hip (Cotton). *a* The thigh is flexed and gently lifted in adduction with the leg in flexion, *b* the thigh is rotated inward (foot outward), *c* the thigh is abducted and rotated upward, *d* the thigh is abducted, *e* the thigh is rotated outward (foot inward), *f* the leg is extended. This is done with a sweeping circular motion without force. In the diagram the heavy arrow indicates the sequence of positions.

then extended. If the head does not pass in the leg is rotated outward and lifted again.

Bigelow method. The thigh is flexed gently lifted in adduction with the leg in

flexion rotated inward (foot outward) adducted rotated upward abducted rotated outward (foot inward) and extended This is done with a sweeping circular motion with out force (Fig. 430)

**ANTERIOR DISLOCATIONS—Symptoms—**Anterior dislocations are very uncommon resulting from injuries which cause extreme abduction of the leg. The head twists out of the acetabulum tears the lower part of the capsule and rotates forward. The Y shaped ligament is uninjured. The thigh is abducted and rotated outward in extension. The head of the femur may be palpated in the groin below Poupert's ligament.

**Treatment—**Allis method. The thigh is flexed and abducted. An assistant places one

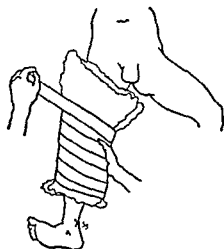


Fig. 431—Application of a compression bandage to the knee. The leg is flexed at the knee. The bandage is secured tightly with an elastic bandage.

hand in the groin and pushes the head outward and backward while the surgeon lifts and adducts and finally extends the leg.

**Bigelow method.** The thigh is lifted and abducted rotated inward (foot outward) and extended.

**Prognosis—**After reduction the patient should be kept in bed for two weeks usually with the feet tied together. There is no reason why weight bearing should not be begun after three weeks and continued with care. As the rent is at the bottom of the capsule there is no reason for recurrence in ordinary use of the hip.

**Dislocations of the knee—**Dislocation of the knee occurs very rarely. The writer has seen only three cases. The dislocation

may be anterior or posterior.

**Etiology—**A fall on the flexed knee causes the dislocation.

**Diagnosis—**The deformity is obvious. In anterior dislocations the crest of the tibia is higher than the thigh. In posterior dislocations it is lower.

**Treatment—**The dislocation is reduced by gentle traction on the lower leg. The bones usually slip into place. Sometimes more manipulation is necessary. The muscle power of the thigh must be maintained through exercises.

**After Treatment—**A plaster of paris splint should be worn for six to eight weeks and protection continued for some weeks thereafter. There has been considerable tearing of the capsule and one must expect some limitation of motion.

**Dislocations of the Patella—Etiology—**These dislocations are more common in women. They are associated with knock knees and may be caused by direct injury to the patella or severe blows, often being the result of a fall with the knees flexed and adducted. The displacement is always outward.

**Pathology—**The ligaments and tendons about the patella are torn.

**Symptoms—**The knee is flexed with pain and swelling. The intercondylar fossa is empty. There is usually hemorrhage into the joint and the patella can be palpated outside the condyle.

**Treatment—**Under anesthesia the knee is flexed and the leg extended. Compression dressings will reduce the hemorrhage into the joint. Atrophy of the muscles of the thigh may be minimized by exercises before and after operation.

**Prognosis—**So much injury has been sustained by the ligaments that recurrent dislocations are frequently reported especially in childhood because of knock knees and other anatomical conditions. Surgical intervention may be required to direct the power of the quadriceps muscle toward the weight bearing line and to repair old tears in the capsule.

**Dislocations of the Ankle.** (See section on Fractures about the Ankle Joint).—Practically all fractures of the ankle have associated with them some degree of dislocation. The reduction of the fracture carries with

## DISLOCATIONS OF THE ASTRAGALUS

it the reduction of the dislocation. Uncomplicated dislocations of the ankle are rare and occur only forward or backward because of the depth of the ankle mortice. In *posterior dislocations* the lateral ligaments are lacerated, and the astragalus is forced backward beyond the tibia. *Anterior dislocations* are very rare.

**Diagnosis**—The position of the foot readily indicates the diagnosis, which can be confirmed by means of roentgenograms.

**Treatment**.—In cases of posterior dislocation

inner side of both heels (Thomas heel inside being raised  $\frac{3}{8}$  inch and built for  $\frac{1}{4}$  inch).

**Dislocations of the Astragalus.**—*ogy*.—These dislocations result from or a twisting of the foot, usually associated with considerable violence. The astragalus is partially or incompletely torn out of position. A *subastragalar* dislocation is rare but must be kept in mind for occurs, it must be promptly reduced (open reduction (prompt) is necessary

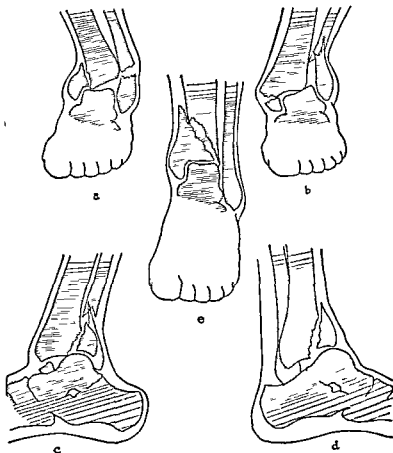


Fig. 432.—Fracture-dislocations of the ankle. a, Inward; b, outward; c, posterior; d, anterior; e, upward.

tion the lower part of the leg is pushed backward and the heel forward. In cases of anterior dislocation this motion is reversed; the lower part of the leg is pushed forward and the heel backward. Usually no difficulty is experienced in effecting a reduction.

**Prognosis**.—The foot should be kept in dorsiflexion at right angles to the leg from four to six weeks. Early active motion with the cast in place is recommended. During convalescence the foot should be strapped in inversion. It is also well to build up the

**Diagnosis**.—The articular surface of the astragalus is palpable inside and in front of the ankle. There is much tension of the ligaments. Roentgenograms are difficult to interpret because of the distortion of the bones. The dislocation is often compound, and the blood supply of the bones is damaged.

**Treatment**.—An attempt should be made to effect reduction by manipulation, spreading the joint on the side of the tibia and pushing the astragalus back into place. If closed reduction is impossible, open

ation is necessary. Excision of the bone gives poor results. Fusion of two adjacent bones is more satisfactory.

In cases of compound fracture the joint should be cleaned and the bone replaced. This however is a dangerous procedure and in many cases amputation of the foot is necessary. A compression bandage and plaster splint are applied and the protection of a splint is needed for from six to twelve weeks.

**Dislocations of the Tarsometatarsal Joints**—One or more metatarsals may be dislocated laterally on the tarsal bones.

*Diagnosis*—Roentgenographic examination is necessary to demonstrate the lateral displacement.

*Treatment*—If treated early a dislocation is easy to reduce but difficult to fix because of the flatness of the joints. Fixation in a molded plaster of paris splint is sometimes successful but it is usually necessary to operate and hold the dislocated bone in place with sutures or screws.

*After Treatment*—The foot must be supported for two or three months.

The end results are usually poor.

HENRY C. MARBLE

## XIX. THE HEAD

### THE SCALP

**Anatomy**—The scalp is composed of five layers. Immediately beneath the skin is a layer of subcutaneous fatty tissue made up of small lobules of fat enclosed by many dense fibrous bands uniting the skin closely to the galea aponeurotica. Between the latter and the pericranium is rather loose subaponeurotic connective tissue. Movement of the scalp on the skull is in this loose tissue. As the subcutaneous tissue is very dense, effusions collect in the loose subaponeurotic layer and its close connection with the galea decreases the usual redness and swelling in skin infections. The skin contains many sebaceous glands and it is obstruction of these glands which causes the retention cysts (wens) commonly seen on the scalp. Larger blood vessels and lymphatics are found in the loose subaponeurotic tissue communicating by way of the emissary veins with the intracranial venous sinuses and are thereby a source of dangerous extension of infections. The blood supply through the paired occipital, postauricular, temporal and supraorbital vessels is abundant and widely anastomotic. The pericranium is slightly adherent to the skull except at the sutures where the attachment is firm.

**Cephalhematoma** is the collection of blood between bone and pericranium more frequently seen as an accident of birth or a result of birth injury. It is thought to be related to possible injury of the outer table of the incompletely ossified skull. One or two days after birth there is seen a swelling limited in area to one bone usually the parietal. It is fluctuant and the surrounding skin is dark. The borders may feel slightly thickened owing to the presence of blood clot. Later the pericranium proliferates and if the blood is not soon absorbed may begin to produce bony callus and ultimately a thin layer of bone diffusely over the swelling. From the diagnostic viewpoint it is to be differentiated from caput succedaneum, a circular circumscribed edema of the scalp brought about by prolonged pressure in the birth canal. The latter is not limited by the cranial sutures; it contains a bloody serum; pits on pressure and does not fluctuate. Cephalhematoma usually disappears spontaneously within two or three weeks after birth. If this should not be the case, aspiration is generally useless as any ordinary aspirating needle is too likely to be obstructed

by blood clots. It is then necessary to evacuate the mass through a small incision followed by pressure over the entire area. A sterile sea sponge kept in bichlorid of mercury solution and then wrung dry is invaluable in the application of a firm pressure over the evacuated area.

**Scalp Wounds**—Occasionally a localized blow on the adult scalp is severe enough to bring about rupture of blood vessels and resulting hematoma without actually causing an open wound. When this happens the entire extravasation of blood takes place in the loose subaponeurotic space. It is to be differentiated from a depressed fracture which it sometimes simulates because a firm area at the periphery made up of blood clot may be mistaken for the edge of bone. When there is actually serious doubt whether or not the condition is a depressed fracture an x-ray should be taken or an exploratory incision made. After evacuation pressure is applied. The presence of any skin abrasion should be a danger signal for possible infection which may enter and extend beneath the galea.

An open wound of the scalp may be produced by any localized sharp or blunt force. The scalp is relatively inelastic and the force of a blow expended on the skull causes a rupture of the skin and galea and frequently of the pericranium. Such injuries entail definite risk of infection with wide spread extension beneath the galea. The scalp has a rich blood supply, and hence healing is sometimes surprisingly good even when a considerable area is involved.

**Treatment**—Treatment is determined by four factors: the character of the wound, the condition of the tissues, the amount of swelling and the time which elapses between the injury and surgical care. A clean incised wound without tissue destruction seen within six hours of the injury should be sutured. A grossly dirty contused wound if seen more than six hours after injury should not be treated by primary suture. Between these examples of mild contamination and



frank infection are occasions which call for individual surgical judgment. Painsstaking cleaning combined with modified wound excision will frequently permit primary suture of wounds which otherwise should not be closed. Dry sterile gauze is first placed in the wound and the involved parts are shaved after softening with green soap. Local anesthesia is preferable in all cases when reasonable cooperation of the patient may be expected. The surrounding skin is then scrubbed thoroughly with soap and water. Hydrogen peroxide is useful for removing dried blood but should be kept out of the wound. Ether is useful to remove grease and may be used in the wound without ill effect. One of the tinted antiseptics is then used on the skin up to the wound edge. Following this preparation and after removal of the gauze the wound is irrigated with liberal amounts of saline solution and examined thoroughly both for the presence of foreign bodies and the possibility of bone injury. Ostensibly crushed and devitalized tissue should be removed (debridement). Complete wound excision is not usually practicable in the scalp. Bleeding usually can be controlled by pressure on visible sources but when it is persistent sutures properly placed are preferable to ligatures. Interrupted sutures of silk or cotton are used both in skin and in galea. Bare bone should always be covered. When loss of tissue necessitates shifting of adjacent scalp the separation is made through the galea and the secondary defect covered immediately by a split skin graft or after several days. Extensive laceration of the scalp may be so severe as to be almost an avulsion. However extensive there is sometimes left a large pedicle with sufficient blood supply so that suture in position is followed by healing.

**Avulsion of the Scalp**—The commonest cause of complete avulsion is an industrial accident usually to a woman. The separation takes place between galea and pericranium which is usually left attached. If untreated the latter soon disappears exposing the cranial bones. The blood supply following this accident is usually inadequate so that the cranial bones soon assume the dry yellowish appearance typical of slow necrosis, the degenerating bone being cast off very slowly.

**Treatment**—After the patient's recovery from shock all parts of the scalp which are not obviously devitalized should be replaced and bleeding controlled by ligature and suture. Denuded bone should be covered by the flaps and exposed pericranium should be split skin grafted either immediately or within a few days. If these grafts fail it is advisable very early to make multiple perforations of the outer table of the skull thus stimulating the diploe to form granulation tissue. This will in time cover the entire denuded area and offer a sound base for skin grafting. These perforations should be about 1 cm. apart and should penetrate the outer table until definite bleeding occurs.

Tetanus antitoxin should usually be administered and gas bacillus antitoxin will be definitely indicated in many cases of extensively contused wounds. Sulfanilamide powder sprinkled in these contaminated wounds has many advocates. Since the sulfonamides are inhibited by procaine (novocain) which is a para aminobenzoic acid derivative, nupercaine is preferable for local anesthesia when local sulfonamide is used. If effective sulfonamide medication is desirable oral sulfadiazine best answers the purpose. Penicillin will be useful.

Wounds which are suspected of being infected should be examined daily for at least four days. The presence of infection may not manifest itself by redness of the skin but rather by a shiny boggy and tender swelling which may extend for some distance away from the incised area. Infections of this sort should be treated according to the methods outlined under infections of the scalp.

**Infections of the Scalp**—Apart from wound infections the common infections of the scalp are furuncles and carbuncles and the infections secondary to the presence of pediculosis, ringworm and impetigo. Erysipelas and cellulitis may follow trivial wounds or abrasions. Both furuncles and carbuncles are more common posteriorly on the part of the scalp near the neck. The thick skin predisposes to downward extension rather than spontaneous discharges of pus. This downward extension may extend through blood vessels and through the subcutaneous tissues to the intracranial sinuses. When infection has penetrated beneath the galea its spread is rapid and eradication dif-

sult. Considerable pain and neighboring edema develop accompanied by fever, leukocytosis and regional lymphadenitis. If wound infection is limited removal of one or two stitches and the use of warm compresses will often be sufficient. If the infection has definitely extended beneath the galea it is necessary to insure drainage of this area. Small incisions should be placed in dependent portions of the swollen area and small rubber drains in the subperiosteal space. When the pericranium has been lacerated the infection may spread beneath it. In such a case it is limited in its spread by the strong attachments of the pericranium to the cranial sutures.

Osteomyelitis of the cranial bones may follow infections and separation of the periosteum. The latter soon perforates and pus accumulates in the subperiosteal layer. This is frequently referred to as Pott's puffy tumor and may also be accompanied by a collection of pus between the bone and the dura.

The treatment of any infection of the scalp is based on careful recognition of the layers involved. Adequate drainage is necessary especially in dependent portions. Sometimes these incisions must be so extensive as to seem unnecessarily radical but the unsatisfactory results following conservative treatment speak for themselves.

**Burns of the Scalp**—These are better treated by other methods than tannic acid coagulation. When the patient is first seen it may be difficult to estimate the depth of the injury and it is important that all structures not destroyed by the burn be preserved. Hair follicles, galea and even pericranium that have not been burned may be destroyed by tanning. These burns should be treated with sterile petrolatum or boric acid ointment applied on fine-meshed gauze reinforced by moderate pressure. Many burns treated in this manner will not need grafting as epithelialization will proceed from the corium and the bases of undestroyed follicles. However, once it becomes apparent that such epithelialization is not proceeding skin grafting should not be delayed. If a granulating surface is allowed to heal by peripheral epithelial growth an unstable scar results. If pericranium has been destroyed exposing the outer table of the

skull treatment depends on the viability of the latter. Early multiple perforations will allow the diploe to granulate but it may sometimes be time saving to remove areas of the outer table. A split skin graft is best in this location.

**Tumors of the Scalp**—The common tumors of the scalp are basal and squamous cell epitheliomas. They may originate in unstable scars from the lining of sebaceous cysts from senile keratoses or from apparently normal skin. These tumors should be excised with a good margin particularly on the lymphatic drainage side. Closure of the defect offers no problem as the circulation of the scalp allows it to tolerate marked insult. Relaxation incisions, sliding or rotating flaps and split skin grafting are useful here. When the skull is involved either by the tumor itself or by irradiation osteonecrosis it must be removed. The dura thus exposed must be covered immediately as its ability to produce granulation tissue suitable for grafting is almost negligible. For small defects single-pedicule flaps may serve but for larger ones a double pedicle flap made up of an entire segment of scalp must be used and the donor area covered with a split graft.

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## INJURIES AND SURGICAL INFECTIONS OF THE EYES AND ADNEXA

The most frequent injury of the eye is caused by the deposit of a foreign body on the cornea. Care in removing a foreign body completely under aseptic precautions is most important because if it is neglected or improperly removed a severe purulent keratitis (serpiginous ulcer) may result, often leading to loss of the eye. When seen late if the slightest gray or yellowish infiltrate is present this must be sterilized by the careful application of pure trichloroacetic acid or tincture of iodine and the eye watched carefully.

*Intraocular foreign body is to be suspected after any injury to the eye even a seemingly trivial one.* In such cases roentgenograms should be made by a method which will localize the foreign body with relation to the globe. The Sweet method is usually employed but if proper instruments and tech-

nics are not available the insertion of small pieces of silver wire under the conjunctiva above and below the cornea will usually provide the necessary information when they are seen in frontal and lateral views. They are inserted under local anesthesia through minute conjunctival incisions and are removed after the roentgenograms have been taken.

If the foreign body is located in the orbit but outside the globe it may usually be left unless it interferes with the movements of the globe or infection develops. If it is located inside the globe and is of some magnetic material it should be removed at once with a magnet. One of the giant models is usually necessary though larger particles may sometimes be removed with a small hand magnet. If the nature of the foreign body is unknown a trial with the magnet will determine whether or not it is magnetic. This should not be undertaken however unless the body has been properly localized. As much care must be taken in such a trial as in removing the foreign body. Opinions differ as to the best route for removal of a foreign body in the posterior segment. A skilful operator is usually successful in drawing the fragment around the lens into the anterior chamber whence it is removed through the original wound or through a small section at the limbus. Others will prefer to remove it directly through a scleral incision near its site.

Non magnetic foreign bodies can seldom be removed unless they are in the lens or anterior chamber. An eye which is harboring a foreign body is a possible source of sympathetic ophthalmia but may remain quiet with more or less useful vision for many years. Hence it is usually best to watch such an eye closely for signs of iridocyclitis and if the signs occur and do not respond rapidly to treatment the eye should be removed. Injections of foreign protein, large doses of sodium salicylate or sulfanilamide and the local use of atropine comprise the usual treatment in a case of intraocular foreign body.

Lacerations of the lids may usually be repaired at once unless seen after infection has developed. The wound is first washed with sterile saline solution and touched with half strength tincture of iodine. The con-

junctival sac may be washed out freely with 1:2500 metaphen or a similar antiseptic. Careful apposition of the edges at the outset will save much work later in correcting cicatricial deformities. Because of the excellent vascular supply the introduction of drains is seldom necessary. An exact knowledge of the anatomy and function of the parts is necessary for proper closure of an extensive wound of the lid. When a wound involves the entire thickness of the lid it is important to close the conjunctival wound separately as otherwise bands of scar tissue will develop and interfere with the movements of the globe or with the wearing of a prosthesis. Even though it may be difficult to open the lids the exact condition of the globe must be ascertained. In the case of a dirty wound of the lid or globe a prophylactic injection of 1500 units of tetanus anti-toxin should be given at once.

In the case of a perforating wound of the globe one must decide whether or not the eyeball may be preserved. If no vision is present or only perception of light with faulty light projection it is usually best to sacrifice the eye or its contents as the prospect of regaining useful vision is nil and retention of such an eye may involve the danger of sympathetic ophthalmia. When useful vision or even correct projection of light is present an attempt is usually made to save the eye. A small wound in the corner without prolapse of the iris will often heal smoothly if both eyes are immobilized under a dressing which should include a rigid shield to prevent further trauma to the globe.

If the wound is large and includes a prolapse of uveal tissue it must be closed by covering it with a sliding conjunctival flap. Direct closure by sutures through the cornea or sclera involves too much traumatism to the eye with possible loss of vitreous or damage to the lens. Careful local anesthesia and injection of 4 per cent novocain at the outer orbital margin to paralyze the orbicularis muscle are essential preliminaries. The conjunctiva is gently dissected away from the wound and undermined so that it may be pulled over it with the slightest traction. Two or more stitches are inserted in such a position as to pull the conjunctiva well over the wound when tied and one turn of each knot is placed while

the stitches are left loose. The wound is touched carefully with pure liquefied trichloroacetic acid and if the cornea is involved it is also applied carefully to the under surface of the flap so that it will adhere to the cornea. Then and not until then the prolapsed uveal tissue is cut off with one snap of sharp iris scissors and the stitches are tied. Previous excision of the prolapse would allow the escape of vitreous or the lens during subsequent maneuvers. Atropine is instilled a dressing with a rigid shield is applied and the patient is put at rest. As a prophylactic against infection an injection of foreign protein is usually administered and in the case of a dirty wound this may well be tetanus antitoxin. Sodium salicylate is administered after twenty-four hours.

The watch for complications then begins the commonest of these being intraocular infection. If many pyogenic organisms have been introduced a purulent infection will rapidly manifest itself and will usually require excision of the ocular contents. Milder forms of infection often occur which may subside under treatment with foreign protein and the salicylates or sulfanilamide. If the reaction following an injury is not subsiding after two weeks of treatment the eye must often be sacrificed in order to prevent sympathetic ophthalmia.

*Enucleation of the globe* is the operation usually performed. The conjunctiva is dissected from the limbus and is then undermined all around and far back on the globe. The four rectus muscles are caught on a hook and cut off at their insertions.

Strong curved enucleation scissors are inserted beneath the conjunctiva at the nasal side until the optic nerve is felt. This is cut quickly while the globe is pulled forward by fixation forceps attached to the stump of the external rectus. The remaining attachments are then cut including the attachment of the two oblique muscles. A purse-string suture may be used to close the conjunctiva though this is not necessary. This operation if performed without injury to the conjunctiva allows the wearing of a prosthesis. The stump left is small however and usually a glass or gold ball is inserted in Tenon's capsule and the muscles and capsule are carefully sutured over it.

An operation which leaves a stump at least as good as that obtained by an implant in Tenon's capsule is *simple enucleation* of the ocular contents. An incision is made from the outer ciliary region bisecting the cornea and anterior segment to the inner ciliary region. An excision spoon is inserted and the entire uveal tract, retina and lens are removed at one scooping movement. The inside of the sclera is wiped carefully with large sponges so that no shreds of uveal tissue remain. The corneal incision is not sutured but is held together by a large glass ball (2 cm in diameter) or by a sponge placed beneath the lids and held in place by a dressing for forty-eight hours. This operation is suitable in an early wound and if a purulent infection of the globe is already present. When sympathetic ophthalmia has developed or its presence is suspected enucleation is the surgical procedure to be preferred.

*Traumatic cataract* is a common complication of penetrating wounds and may occur even after blunt contusion by rupture of the lens capsule. If the lens swells rapidly causing pain and increased intraocular tension it must be removed at once. More commonly swelling is slight but the whole lens becomes opaque within a variable period. In such cases removal is deferred until all signs of reaction have subsided—usually after several months. In some cases a localized opacity of the lens occurs which remains stationary with little or no disturbance of vision and removal of the lens is not required. In persons under the age of thirty, the lens material is soft and may be removed by gentle pressure through a small corneal incision. In older persons a hard nucleus is present and a larger limbal incision with a conjunctival flap is required. A patient who has had one lens removed the other eye being normal will usually prefer not to wear the strong convex glass which is required for good vision. However this should not deter the surgeon from advising removal of the traumatic cataract when the opacity is complete as useful vision is present without correction and the eye is placed in the best condition against the time when it may be needed.

## CANCER OF THE LIP

**Definition**—The term cancer of the lip is usually limited to those growths arising on the vermilion border or on the mucocutaneous junction of the lips. Lesions arising on the skin separate from the vermilion border should be classified with other carcinomas of the skin of the face.

**Etiology**—Cancer of the lip comprises about 30 per cent of all malignant tumors of the oral cavity. While the most frequent it is the least malignant form of intraoral cancer. The average age of occurrence is 56 years, although in about 10 per cent of cases the growth develops before the age of 40. It is rare in women over 90 per cent of the cases occurring in men. In about 90 per cent of all cases the growth arises on the lower lip where the effects of chronic irritation from exposure to sunburn, dryness, chapping, biting or smoking are most likely to occur. The upper lip is relatively well protected from these etiologic factors and is rarely (5 per cent) affected by primary cancer. Syphilis is not as great an etiologic factor in cancer of the lip as in other anatomic forms of intraoral cancer.

**Pathology**—Cancer of the lip is preponderantly squamous carcinoma grade 2. Papilloma or squamous carcinoma grade 1 may occur. Growths of the lip developing in scar tissue following thermal or radiation burns are likely to be spindle cell carcinoma.<sup>1</sup> Sarcoma of the lip is extremely rare.

**Symptoms and Clinical Course**—Cancer of the lip usually appears as a small plaque or ulcer which is indurated well beyond the borders of any visible disease. Pain and tenderness are characteristically absent. The patient is likely to attribute the lesion to a simple cold sore and fails to seek medical advice until the growth is about 1 cm in diameter. In later stages, widespread invasion, ulceration and erosion of the lip occur with metastases to the cervical nodes.

Metastases tend to appear relatively late but are present in about 25 per cent of cases when the patient is first seen by the physician. The nodes most frequently involved are the submaxillary, next the submental and finally the upper deep cervical. If the lesion is well to one side of the midline the nodes usually appear on the same side.

**Diagnosis**—An early lesion may be confused with herpes, keratosis, benign fissure, leukoplakia or tubercular or syphilitic ulcer. There should however be little difficulty in making a diagnosis. Any indurated ulcer of the lip which persists for more than a month is probably cancer. A syphilitic lesion resembling cancer will disappear after less than three weeks of aggressive antisyphilitic treatment. A tuberculous ulcer presents a pale yellow base without ulceration; it is usually tender and painful and a differential diagnosis can as a rule be made quite easily.

When any doubt exists a biopsy is essential. The specimen should be taken from the indurated edge of the ulcer either with a biting forceps or with a scalpel. Unless the surgeon assumes all responsibility for error a biopsy should be made before either irradiation or surgical treatment is undertaken.

**Treatment**—The treatment of cancer of the lip should be based mainly on a consideration of the pathologic anatomy and on the characteristic clinical course. The primary lesion arises in an anatomic structure which is readily accessible to either radiation or surgical treatment and which may be partly or wholly removed and the defect repaired without serious surgical shock or interference with any vital function. As compared with the other malignant growths of the oral cavity, cancer of the lip is the least malignant and the clinical course is less rapid so that the primary lesion may be treated first. After healing has taken place any cervical metastases may be treated separately. The treatment of the primary lesion and that of the cervical metastases are best considered and undertaken as separate problems except occasionally in the advanced stages of the disease.

For a growth of the lower lip up to 1.5 cm in diameter a permanent cure will result if the primary lesion alone is completely eradicated by any method (operation, radium or x rays) since at this stage of the disease metastases have occurred in only about 10 per cent of cases. This has an important bearing on the management of suspected but nonpalpable cervical metastases—a problem which will be considered presently.

Treatment of the small or moderate-sized lesion is equally successful by either surgical

excision or radiation if properly applied. The V-shaped excision produces moderate deformity, the degree varying directly with the amount of tissue excised. A safe excision is always a wide one and must extend at least

7 to 10 mm from any visible or palpable evidence of the tumor. Since the surgeon is usually influenced by the desire to avoid a great degree of cosmetic defect, he frequently



Fig. 133.—Cancer of the lip treated with low voltage x rays.

Such radiation may be in the form of radium or x rays. Radium or radon is usually applied in contact with or at short distances from the lesion.

allows too narrow a margin and recurrences are not uncommon. The V-shaped excision is not a difficult operation and may be done with the use of infiltration or conduction anesthesia.



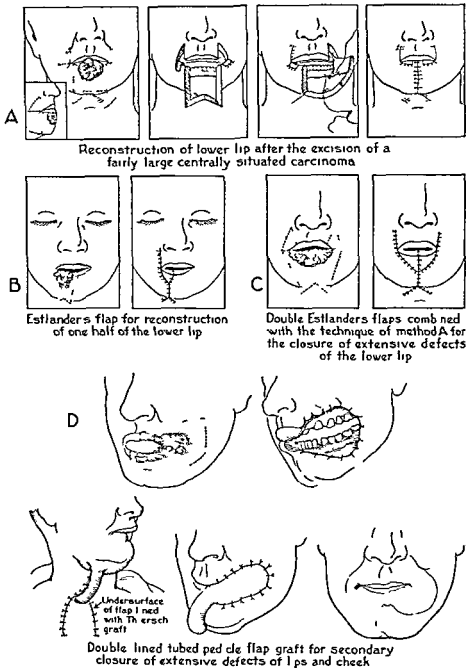
Fig. 134.—Advanced cancer of the lip treated by wide surgical excision and primary closure.

Irradiation of a small or moderate sized lesion has many advantages over surgical ex-

cision. Radium or radon needles or seeds inserted into the growth are sometimes advocated but when used alone are likely to result in undue scarring or delayed healing. Low voltage, lightly filtered x radiation applied to the lesion after careful protective shielding of the adjacent normal tissues is one of the

most satisfactory methods (Fig 433) A moderately advanced lesion sometimes requires a combination of external radiation (x rays or radium) and small doses of radon seeds implanted into the deepest infiltrating

not easily controlled by radiation except with intense doses which are often followed by delayed or imperfect healing with a resultant defect (Fig 434) In such cases it is impossible to obtain a good cosmetic re



Reconstruction of lower lip after the excision of a fairly large centrally situated carcinoma

Estlander's flap for reconstruction of one half of the lower lip

Double Estlander's flaps combined with the technique of method A for the closure of extensive defects of the lower lip

Double lined tubed pedicle flap graft for secondary closure of extensive defects of lips and cheek

Fig 430—These basic methods alone or in combination with slight modifications may be successfully used for the repair of almost any defect which is likely to result from excision of extensive cancer of the lip

base of the lesion. A discussion of the details of the technique and dosage is beyond the scope of this chapter.

Advanced bulky infected cancer of the lip which has invaded or eroded deeply is

sult and all efforts should be directed toward the saving of life with an acceptable functional result. Such a purpose is accomplished most expeditiously by wide surgical excision and plastic closure (Fig 430) provided any

cervical metastases if present also permit of a reasonable chance of control. A wide extent of the disease in the lip or even invasion of the mandible does not always preclude complete eradication and acceptable functional closure of the defect by aggressive surgical treatment.

In such extensive cheiloplasties excision of the lip and excision of palpably involved cervical nodes are usually performed at the same time. It is unwise to attempt radical or complete neck dissection in connection with such an operation. It is of great advantage if the surgeon is also a competent radiologist and has radon seeds available for the implantation in any unremovable portions of the growth. He should employ radiation for widely separated single nodes after an extensive operation rather than attempt to control by more extensive dissection of the neck.

Treatment of cervical metastases in cancer of the lip is a serious problem. Provided the primary lesion is under control the nodes are operable and the general condition of the patient will permit of a major surgical procedure neck dissection is often a useful and effective measure in a case of cancer of the lip for palpably involved cervical nodes. The procedure should preferably be performed with the use of local anesthesia and since the metastases from cancer of the lips in the operable stage seldom extend beyond the submaxillary and upper deep cervical region the dissection need not extend below the level of the omohyoid muscle in most cases. The submental region should always be included.

For metastatic nodes which are inoperable because of deep fixation or because of the general condition of the patient a combination of external and interstitial radiation is often successful. Such treatment is applied only locally to the single node and may be repeated if and when further nodes appear.

It has been found on analyses of large series of cases of cancer of the lip that when these patients present themselves without palpably involved cervical nodes permanent cure will follow adequate treatment of the primary lesion alone in 90 per cent of cases that is to say in only 10 per cent of this group will metastatic cervical nodes develop subsequently. Despite this significant fact

some surgeons advise prophylactic neck dissection in the absence of palpably involved nodes. The illogic of prophylactic neck dissection in cancer of the lip is apparent when one considers that the procedure can be of possible value in only 1 of 10 cases while carrying with it a mortality of 5 to 10 per cent.<sup>3</sup>

Prophylactic radiation in the form of one or two skin erythema doses to each side of the neck also seems illogical since this dosage does not produce any noticeable effect on cancer of the lip when actually present. Radiation in lethal doses for cancer (six to eight skin erythema doses) to the entire potential metastatic region in the neck is beyond the point of average tolerance and for that reason it seems most reasonable to give no treatment whatever to the neck in cases of cancer of the lip unless there is palpable evidence of metastases.

**Prognosis and End Results.**—Cancer of the lower lip is the least malignant form of intraoral cancer. In early cases in which the lesion is 1.5 cm. or less in diameter a cure should be obtained in practically 100 per cent of cases if the patient is regularly observed and examined for recurrence. Failures often result from inattention to proper follow up either by the patient or by the physician. Cancer of the upper lip is a more malignant form of the disease and has a worse prognosis than that of the lower lip.

Various percentages of cure are reported in the literature, the higher figures invariably being based on selected early cases or cases in which the growth was operable. A recent survey at the Memorial Hospital, New York,<sup>4</sup> which included all patients admitted (early, recurrent and hopelessly advanced cases) gave a net five year rate of cure for 70 per cent when surgical treatment or radiation or a combination of the two was given as indicated in the individual case.

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## CANCER OF THE TONGUE

**Definition**—The term cancer of the tongue should include all malignant growths arising on the surface or in the body of that organ. The surface limits are posteriorly the valleculae and anteriorly and laterally the junction of the tongue with (but not including) the floor of the mouth. Growths originating in the mucosa of the floor of the mouth anteriorly or laterally possess clinical and anatomic characteristics deserving of a separate classification. The disease is almost invariably of epithelial origin and therefore arises on the surface.

**Etiology**—Cancer of the tongue is one of the most common anatomic forms of malignant growth of the oral cavity and comprises about 20 per cent of all intraoral tumors. It is mainly a disease of middle or old age but 25 per cent of the patients are less than forty years old. As in all forms of intraoral cancer lingual cancer is preponderantly a disease of men (87 per cent). The disease tends to occur at an earlier age in women than in men. The sites of origin in the order of their frequency are the middle third of the lateral border (55 per cent), the base (30 per cent) and the anterior third (15 per cent). The point of origin is commonly on the border rather than on the dorsum of the tongue. Apparently chronic irritation is an outstanding etiologic factor in growths of the middle and anterior thirds and it is probable that the chronicity of the irritant is more important than its nature.

**Tobacco**—One of the most common causes of chronic irritation of the oral mucous membranes is the use of tobacco but since this habit is so common and the degree of indulgence so variable and irregular it is difficult to assess the degree of its influence in the etiology of cancer of the tongue. Over-indulgence in tobacco has been an obvious cause in many instances. The lesser susceptibility of women to intraoral cancer has often been ascribed to a lesser indulgence in the tobacco habit. However if one considers only the non-smokers of both sexes the disease is still more than twice as frequent in men as in women.

**Teeth and Artificial Dentures**—The most obviously responsible form of dental irritation is the presence of a sharp tooth (broken or worn) or of an ill fitting denture directly in contact with the carcinomatous ulcer.

**Syphilis** is one of the most important factors in the etiology of lingual cancer largely through its capacity for local manifestations in the form of syphilitic glossitis and its sequelae. The Wassermann reaction will be found to be positive in about one third of the cases of lingual cancer. In most cases the infection has been of long duration (fifteen to twenty years) thus permitting the degenerative tissue changes which follow long standing syphilitic glossitis. Syphilitic infection of short duration is of doubtful etiologic significance since time must elapse for these degenerative changes to take place.

**Leukoplakia**—In a susceptible subject chronic irritation of the oral mucous membranes (from syphilis or other causes) may result in the development of either leukoplakia or cancer or both. An infiltrating indurated ulcer appearing in a leukoplakic tongue is almost always cancerous.

**Pathology**—By histologic examination lingual cancer has been found to be epidermoid carcinoma in about 80 per cent of cases. Anaplastic epidermoid carcinoma and lymphoepithelioma are most likely to occur at the base. An adenoid tumor is rare. Sarcoma of the tongue (myosarcoma) is a rare disease and most of the cases occur in infancy.

**Symptoms and Clinical Course**—In cancer of the anterior two third of the tongue the most common form is an indurated painless non-tender ulcer arising on the edge at the middle third. As it develops the surface usually becomes ruoid, nodular and granular. The ulceration spreads, the induration deepens as the edge of the lesion becomes raised and infiltrated and finally the center becomes excavated. When the growth is 2 or 3 cm in diameter infection commonly occurs and the lesion may become both slightly tender and painful.

In other clinical varieties the morbid anatomy may differ somewhat. In the papillary form which tends to be less malignant the tumor may fungate over a widely ulcerated area but may fail to infiltrate deeply.

In these cases the mucous membrane at the border of the ulcer is raised and everted, and the ulcerated surface presents an irregular papillary and fissured appearance. In other cases the growth apparently arises in the deep layers of the mucosa or in fissures extending and infiltrating deeply so that a large tumor may occupy the body of the tongue with little or no ulceration or alteration in the surface contour. In the so called scirrhus form the involved portion of the tongue is shrunken. In the later stages of lingual cancer more than one clinical variety may be present so that the entire organ may be infiltrated and boardlike with surface ulceration over an area of only 1 or 2 cm. or the growth may infiltrate deeply from its point of origin and may appear on the surface in one or more additional areas by perforation of the mucosa from below.

Until the disease has infiltrated about a third of the tongue or until a fungating tumor at least 3 cm. in diameter has developed there is little actual discomfort or interference with function. At this stage when the muscles of the tongue have been deeply infiltrated surface necrosis of the tumor and hemorrhage may develop with a marked fetid odor of the breath. The local tumor eventually gives rise to widespread ulceration and sepsis followed by increasing interference with motion, fetor oris, dysphagia, trismus, pain and hemorrhage.

Growths arising in the base of the tongue comprise a definite clinical group. The primary lesion is seldom discovered by the patient. Symptoms referable to the tongue or pharynx are entirely absent in over one third of these patients at the time of admission and if present are likely to be vague and misleading since they consist of slight soreness, dysphagia, hoarseness and dyspnea. A tumor at the base of the tongue may ulcerate and reach a diameter of 3 cm. or more without causing any particularly marked local symptoms. The majority of patients with cancer at the base of the tongue seek advice because of enlarged cervical nodes.

At the base of the tongue the tumor may extend downward into the pharynx as far as the pyriform sinus. The edge of the tongue just opposite or anterior to the tonsillar pillar is a common site of origin of the disease. There is little resistance to extension onto

the tonsillar pillar and the tonsillar region. Cancer of the base of the tongue resembles pharyngeal cancer in general in that the growth tends to be anaplastic carcinoma or lymphoepithelioma. The disease runs a more rapid course and metastases appear earlier and more often below the clavicle. Radio sensitivity is the rule.

*Metastases*—In cancer of the tongue metastases are more likely to disseminate widely throughout the neck to the lower deep cervical nodes to the posterior triangle of the neck bilaterally or below the level of the clavicle than is the case in growths of the lip or mucosa of the cheek. The lymph nodes earliest and most commonly involved are the upper deep cervical nodes which are centered at about the bifurcation of the common carotid artery. As the disease progresses other nodes may appear usually below this point along the course of the internal jugular vein. If the primary lesion is widely ulcerated or fissured the metastatic lymph nodes are likely to be complicated by secondary infection.

*Diagnosis*—If cancer of the tongue is suspected a biopsy should be made at the time of the first examination in order to verify the clinical diagnosis. The diseases which may offer some difficulty in the making of a differential diagnosis are in the order of importance syphilis, tuberculosis, superficially ulcerated or fissured leukoplakia and simple granuloma (such as trauma or Vincent's angina).

*Gumma of the tongue*—the syphilitic lesion most closely resembling cancer in that organ is rare and occurs less than 1 per cent as frequently as cancer. These two conditions may be difficult to differentiate clinically and a diagnosis of gumma should not be made except after repeated biopsies have failed to reveal the presence of cancer. The most frequent and tragic errors in the diagnosis of cancer of the tongue are due to confusion of this disease with gumma mainly on the basis of a positive Wassermann reaction. A positive Wassermann reaction alone does not disprove the presence of cancer since syphilis and cancer of the tongue co-exist in about 30 per cent of cases. If an ulcer of the tongue is gummatous it will almost invariably heal after two or at the most three weeks of aggressive anti-syphi-

ilitic therapy (neoarsphenamine every four or five days) There is no use in persisting with the therapeutic test for a longer period Chronic syphilitic glossitis with the widespread verrucous type of leukoplakia should always be suspected of malignant change

In any case there is no excuse for a temporizing or passive attitude in the presence of a chronic ulcer of the tongue Biopsy examination should be made at the first visit Whatever therapeutic tests may be subsequently indicated in the form of antisyphilitic therapy sodium perborate mouth washes for Vincent's ulcers or the extraction of an offending tooth are not interfered with by taking a biopsy specimen

One normal biopsy specimen does not necessarily prove the presence of cancer The ulcerated surface of a malignant growth may be covered by exuberant simple granulation tissue Therefore if the clinical appearance of the lesion so indicates biopsy should be repeated once or even twice

*Tuberculous ulcers* unlike gumma frequently occur on the tongue—usually on the dorsum but occasionally on the borders or the tip They usually present a yellowish unhealthy base with little or no overgrowth of tissue as compared to the coarse granular appearance of cancerous lesions Tuberculous ulcers are more likely to be painful and tender with little or no induration A diagnosis is made with the aid of biopsy (preferably repeated) which fails to show the presence of cancer roentgen examination of the chest and examination of the sputum Tuberculous ulcers of the tongue or other oral mucous membrane are almost invariably secondary to demonstrable pulmonary tuberculosis

*Benign papilloma* of the tongue cannot often be distinguished from the low grade papillary form of cancer except by biopsy Simple granuloma of the tongue due to the trauma of a sharp tooth or an ill fitting denture or to Vincent's infection may be confused with cancer or vice versa Such a lesion should always heal within two weeks after removal of the offending tooth or denture the use of sodium perborate mouth washes or the local application of a solution of neoarsphenamine If the ulcer persists longer than two weeks its nature should be definitely proved by biopsy

*Other benign lesions* of the tongue sometimes confused with cancer include fibroma lymphangioma hemangioma and glossitis rhombica mediana Each of these conditions has definite individual characteristics which should present little diagnostic difficulty

*Cervical adenopathy* may be the first symptom of lingual cancer and even when the primary lesion is perfectly demonstrable by oral examination the presence of cancer is frequently first discovered by excision of a cervical node for biopsy Strange as it may seem cancer of the base of the tongue may be confused with chronic tonsillitis and tonsillectomy may be performed for the relief of symptoms

*Treatment*—In the treatment of lingual cancer two separate problems must be considered first the primary lesion of the tongue and second the cervical metastases

*General Hygienic Measures*—In most instances of cancer of the tongue the hygienic condition of the oral cavity is poor and this complication is always temporarily aggravated by treatment The measures for combating oral sepsis consist of dental hygiene that is cleaning of the teeth by a dentist instruction in the use of a toothbrush mouth washes and irrigations The wholesale extraction of teeth should be avoided because of the danger of subsequent osteomyelitis Ordinarily treatment for concomitant syphilis should be postponed until after control of the growth

The primary lesion may arise in areas practically inaccessible from the beginning to surgical removal or the growth even in its early stages may invade such neighboring structures as the floor of the mouth or the tonsillar region so as to make surgical removal both difficult and dangerous For these reasons radiation has become the generally accepted method of choice for the management of the primary lesion in this disease If a small growth arises in the tip of the tongue or fungates from one of its lateral free borders surgical removal may often be accomplished with a fair chance of local cure but ordinarily the method is much less conservative and less successful than radiation Local surgical removal or partial glossectomy is often indicated in conjunction with radiation

Radiation of the primary lesion is ordi-

narily best administered by a combination of external and interstitial radiation (Figs 436, 437). When the lesion is at the base of the tongue, external radiation is given through the skin of each side of the neck by the daily fractionated method and supplemented by radon seeds inserted through the skin of the suprathyoid region in the midline anteriorly. For cancer of the anterior two

ployed in the treatment of lingual cancer by the use of radium or radon needles inserted through the lingual surface into and about the growth. This method has the following disadvantages. It is difficult to maintain the needles in position and there is the possibility of introducing infection through the puncture wounds. The method has the advantage of permitting withdrawal of the



Fig 436—Moderately advanced cancer of the tongue treated by radiation



Fig 437—Advanced cancer of the tongue treated by radiation

thirds of the tongue, external radiation may be advantageously given perorally (through the open mouth) by the use of metal cylinders of proper size, to limit the diameter of the beam and insure its proper direction.<sup>1</sup> After a series of treatments by fractionated radiation by this means, a supplementary dose of interstitial radiation is given by means of implantation into the tumor.

Interstitial radiation alone is often em-

ployed at the completion of treatment, while gold radon seeds must be left in permanently. The most important complication of any form of interstitial radiation of the tongue is radionecrosis, which is probably more likely to result from the introduction of infection and the too intensely localized radiation than from the continued presence of foreign bodies.

The dosage employed in these several

technical methods of radiation is too complicated a subject for discussion in this chapter and these methods should not be undertaken except with thorough knowledge of the biologic effects and physics of radiation.

Partial glossectomy is often indicated in conjunction with radiation or for the management of its local complications. The actual cautery is to be preferred to either the scalpel or endothermy for lingual surgical treatment. The muscular substance of the tongue may be cut through quite rapidly with a small red hot loop of the cautery with almost perfect control of capillary oozing so that the operative field remains practically dry. Only the larger vessels require clamping and ligation. The lingual artery is usually severed deep in the body of the tongue. It should be isolated and clamped before section if possible.

If radionecrosis is not anticipated in the depth of the wound after excision it is not necessary to perform a preliminary ligation of the lingual artery in the neck, but if such a precaution is considered necessary, the carotid bulb should be exposed, a local anesthetic being used, and the lingual artery (the second branch) should be identified and tied.

*The treatment of cervical metastases* in lingual cancer is a serious problem. About 25 per cent of all cancerous cervical metastases come from the tongue. The involvement is likely to be bilateral or to the opposite side from any portion of the tongue. Surgical dissection of the neck is only of limited value in these cases since this necessarily radical operation cannot be safely performed soon enough to be of service after recovery from the effects of treatment of the primary lesion. Neck dissection in cancer of the tongue is of value chiefly in cases in which cervical metastases arise several months after apparent control and healing of the primary lesion.

If the metastases are present at the beginning the most successful method of treatment is by radiation which can be carried out safely at the same time as the treatment of the primary lesion. External radiation alone is ordinarily not sufficient except occasionally in the more radiosensitive type of growth originating in the base of the tongue. The average metastasis from lingual

cancer is best treated as a single independent focus of the disease by the application of fractionated radiation through a small cutaneous portal just large enough simply to include the node (3 to 5 cm in diameter) and supplemented by the implantation of interstitial radiation in the form of radon seeds either through skin punctures or after surgical exposure of the outer surface of the node.

Since neck dissection is a major procedure carrying with it a definite mortality it is doubtful whether it is ever justified in the absence of definitely palpable cervical metastases in cases of lingual cancer. The value of prophylactic radiation is also doubtful. The application of small doses (one or two skin erythema doses) to the neck is illogical since that amount of radiation is not lethal for lingual cancer. Cancer lethal radiation doses (six to eight skin erythema doses) to the entire potential metastatic node bearing area of the neck (about 95 by 25 cm on each side) is beyond the limit of tolerance of the local tissues and the body organism as a whole.

**Prognosis and End Results.**—A recent survey at the Memorial Hospital, New York,<sup>2</sup> which included all patients admitted (early recurrent and hopelessly advanced cases) gave a net five year rate of cure for 95 per cent when surgical treatment or radiation or a combination of the two was given as indicated in the individual case.

Cancer of the tongue is not only the most frequent but also the most malignant form of cancer in the oral cavity proper. Under modern methods of treatment (radiation and surgical treatment) the prognosis is best for the younger patients. By these methods the prognosis for women is much better than that for men, probably owing to the fact that cancer in women tends to be more radiosensitive than cancer in men.

In about 55 per cent of the early cases of operable cancer cure is obtained. The prognosis is much better for growths of the anterior two thirds of the tongue. Growths of the base of the tongue carry a relatively bad prognosis because of the rather advanced stage of the disease when it is discovered in this area. The presence of metastases when the patient is first seen makes the prognosis less favorable since it indicates a more ad-

vanced stage of the disease. The histologic form of the growth also influences the rate of cure; the prognosis is low grade epidermoid carcinoma being much better than in lymphoepithelioma or transitional cell carcinoma. Antecedent syphilis does not seem to alter the prognosis to any great extent except that cancer arising on the basis of syphilitic glossitis is likely to be multiple.

### HAYES MARTIN

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## SURGERY OF THE NOSE

### (Exclusion of Fractures Neoplasms and Sinuses)

**General Considerations**—For the proper humidification warming and cleansing of inspired air it is necessary that the entire nasal mucosa should function properly. If for any reason the ventilation and drainage of any part of the surface fails trouble ensues. The obstructed area unable to rid itself quickly of dust and bacteria becomes infected. The resulting swelling adds to the obstruction and a vicious circle is established at the same time the remainder of the mucosa unable to cope with the burden of humidifying all of the inspired air becomes dry. This increases the viscosity of the mucous blanket and prevents its being moved along by the cilia not only does it fail to carry away bacteria but it actually becomes a medium for their growth. The attendant irritation ultimately results in hyperplasia which in turn produces deafness permanent respiratory obstruction head

ache anoxia and other more remote ills their nature depending on the location of the hyperplasia.

The underlying causes of the original obstruction may be either functional or structural. Among the former are sudden changes of temperature trauma swimming and occupational irritations constipation hunger allergy menstruation and any other conditions conducive to changes in the circulation. The structural causes which are the more important surgically include deviation spurs and abscesses of the nasal septum traumatic changes in the bony structure hyperplasias of the turbinated bodies exostoses partial or complete atresias (usually of the choana) synechiae bony cysts aberrant teeth adenoids and related lymphatic hyperplasias rhinoliths and other foreign bodies.

### DEVIATION OF THE SEPTUM NASI

#### (Deflected Septum)

**Definition**—An asymmetrical malformation of the nasal septum involving the cartilaginous portion the osseous portion or both producing a deviation from the midline and obstructing one or both nasal chambers to some degree.

**Etiology**—While in some cases the deviation may be of traumatic origin the asymmetry is ordinarily the result of a redundancy of the structural elements of the septum so that there is a crowding bulging or buckling of this partition within the confining walls of the limiting bones. For this reason the condition is relatively rare in children under the age at which the bony growth of the skull is completed. It is likewise rare in Negroes.

It is probable that the deformity may be due to one of two causes. Either the gothic arch of the infant palate fails to flatten out because of some defect in the development of the maxillary bones thus restricting the space demanded by the growing septum above it or an overgrowth of the septum itself occurs. Straight septums are often found associated with high gothic arches and deviated ones with flat roman ones—evidence in favor of the redundancy theory.

**Morbid Anatomy**—There are several types of septal deviation (1) a simple unilateral bulge more or less continuous from

top to bottom causing obstruction of one nasal chamber and overpatency of the other (2) an S shaped buckling which obstructs one side above and the other below (3) a lengthy ridge which is a modification of the first type in which the bulge has exceeded the limit of elasticity of the structure and produced a sharp edge (4) an advanced stage of the latter in which there is an actual crumpling of bone and cartilage causing irregular ridges and sulci on both sides and (5) the most common type in which the lower margin of the cartilage is displaced from its groove in the crest of the spina nasalis of the maxillary bone and extending downward beside it makes its appearance in the nostril

**Symptomatology**—Occurring as they do somewhat fortuitously, these irregularities

of the septum vary. It may be said of septal spurs that they differ from sharp deviations only in that the opposite surface of the septum remains flat instead of presenting a corresponding concavity the discrepant space being filled with the bony or cartilaginous elements of the structure. Since the symptomatology and the treatment of the two conditions are identical the distinction is academic.

Hematoma and abscess of the septum both causing obstruction are differentiated by their lack of rigidity sometimes even fluctuation on pressure by the history of local systemic reactions and blood cytology. Atresias are distinguished by their continuity with the lateral walls although posterior rhinoscopy may be necessary to determine this.

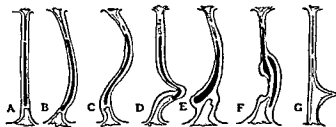


Fig. 438—Typical deviations of the nasal septum: a straight septum; b unilateral bulging; c bilateral buckling; d sharp unilateral ridge; e displacement of the lower edge of the cartilage, which may appear in the nostril; f fracture of the cartilage with overhanging; and g septal spur.

may obstruct the nasal chamber at any point and to any degree. Consequently the symptoms are those related to the affected part: restricted breathing, obstructed sinus drainage, pressure on nerve trunks or the nasal (sphenopalatine) ganglion, irritation and subsequent hyperplasia of the tissues surrounding the orifice of the auditive tube with diminution in hearing and infection through lack of drainage with attendant exudates (mucoid, purulent or sanguineous depending on the invading organism). It should be borne in mind that the air currents passing through restricted spaces and through over patent chambers may be even more active in the production of inflammation than the pressure of ridges and spurs; hence unilateral symptoms are quite as likely to be encountered on the open side as on the obstructed one.

**Diagnosis**—There are few conditions which are likely to be mistaken for deviation

**Prognosis**—Although some deviated septums offer mechanical operative difficulties, the results in experienced hands are uniformly good. Prognosis of the secondary effects of the deviation such as deafness and sinus disease depends on the extent of the damage and somewhat on the age of the patient and the recuperative powers of the mucosa.

**Treatment**—If any treatment at all is required it is necessarily surgical.

**Submucous Resection**—This ingenious operation was first proposed by Killian and developed by Freer and many others. It is usually performed under local anesthesia. It consists in removing the distorted rigid structures—bone and cartilage—from between the two covering sheets of mucosa without disturbing the latter.

This is accomplished through an incision on one side of the septum—usually the convex extending from the anterior angle of the nasal fossa to the floor just

behind the mucocutaneous junction This incision is made into the cartilage but not through it With a flat elevator the perichondrium is separated from the cartilage and continuously the periosteum from the bone over the entire area of the deviation The original incision is then deepened to include the entire cartilage but not the perichondrium on the other side By pressing on the intact side the edge of the cartilage is presented in the wound where it is readily separated from the perichondrium of the second side The mucosa of this side is elevated over an area to correspond with the opposite one With suitable biting and cutting instruments the thin sheets of cartilage and bone are removed and the thick bony ridge which is usually found along the floor is removed with a chisel or fractured with strong forceps A light splinting of petrolatum impregnated gauze strips inserted in both nostrils holds the membranous flaps in apposition It should be permanently removed at the end of twenty-four hours Except for careful cleaning no after treatment is required Hemorrhage is occasionally severe This occurs only when the membrane is torn and is controlled by packing If when the membranes are elevated lacerations of both membranes occur at opposing points a perforation of the septum will result This does not ordinarily follow when only one side is torn and the other remains intact although even here infection may intervene and destroy the imperforate side A perforation is of no great consequence and the patient is usually not aware of it unless it happens to be small circular and anteriorly placed in which case it produces a whistling sound during breathing The remedy is to lengthen the opening posteriorly to form a slit which will not produce a whistle Large anterior perforations gather secretions which dry and form exceedingly annoying crusts Hematoma and abscess of the septum are more serious complications of the septum operation

### HEMATOMA AND ABSCESS OF THE SEPTUM

**Definition**—A collection of blood or of pus beneath the perichondrium or the periosteum in the intact septum or between the opposing membranes following a submucous resection

**Etiology**—Hematoma of the septum is usually the result of trauma and while it was formerly encountered chiefly in children the automobile now distributes it impartially to all ages It occurs after a submucous resection, more frequently in those carefully performed operations in which no tears occur and the incision is closed and splinted Some operators habitually slit the membrane along one side of the floor of the nose at the finish of the operation if no tear has accidentally been made to guard against the retention of blood If the hematoma becomes infected an abscess occurs

**Diagnosis**—These conditions are usually bilaterally obstructive They may be readily diagnosed by palpation if their appearance leaves any doubt Fever, local heat and swelling and the accompanying leukocytosis announce the infection of the hematoma and the onset of the abscess

**Prognosis**—If left untreated they may result in deformity, either in a thickening of the septum or in the case of the abscess in a destruction of the cartilage of the nasal ridge producing a 'saddle nose' Cases of meningitis have been reported following septal abscess

**Treatment** is the same in both cases—free incision near the floor of the nose It may be necessary to maintain drainage for several weeks by means of a strip of gauze laid into the wound which should not be permitted to close until all likelihood of recurrence is past Irrigation of the cavity is commonly frowned on as it may result in further elevation of the membrane and extension of the process Sulfonamides by mouth are useful

### NASAL HYPERPLASIAS (Chronic Hyperplastic Rhinitis)

**Etiology**—Constant local irritations the result of badly disturbed breathing industrial fumes and dusts or infection of a neighboring sinus eventually produce a thickening of the epithelium and a fibrosis of the tunica propria especially in the erectile portions of the turbinal mucosa Here as elsewhere the connective tissue is laid down along the vascular channels and the uneven contraction of this tissue produces corrugations and irregularities of a membrane already thickened and swollen These hyperplasias often interfere with respiration sinus drainage or the ventilation of the auditory tubes Not infrequently the underlying periosteum and bone are involved in the process

**Symptoms**—The symptoms are those of nasal obstruction pressure and sometimes pain varying with the extent and location of the hyperplasia

**Treatment** is preferably preventive The early correction of deformities and the eradication of infections by removal of the irritating cause prevent the progress of in



inflammation to the hyperplastic stage According to Wright the formation of actual fixed connective tissue requires much longer and occurs much later than is ordinarily supposed

After the fibrosis becomes established however the treatment must consist of destruction or removal The first may be accomplished with the actual cautery or a high frequency cautery It is possible with a properly insulated needle electrode to confine the destruction to the submucosa thus preventing the scarring of the ciliated epithelium The usual method of removal especially when bone is involved is with chisel and snare or with one of the many punch forceps designed for the purpose

### ATRESIA NASI

This is a comparatively rare condition It may be the result of syphilis lupus or injury but is usually congenital The anterior atresias are membranous Posterior atresias occurring slightly ventral to the choanae may be either bony or membranous or a combination of the two They may be bilateral or unilateral and cause little trouble and may remain long undiagnosed if unilateral

The treatment is operative and is often unsuccessful

### ABSCESSES ABOUT THE NOSE (ALA COLUMELLA AND LIP)

These abscesses should be mentioned particularly in order to stress the importance of their proper treatment Although it would seem that the venous drainage of the superficial portions of the nose should be through the anterior facial veins plexuses and communicating veins actually form a fairly direct tract through the ophthalmic veins from the forehead the external nose the cheeks and both lips to the cavernous sinus

Abscesses in these parts should be treated with hot fomentations and the patient should be confined to bed Incision should be avoided Numerous fatalities have followed incisions cavernous sinus thrombosis having occurred Early and judicious use of penicillin or sulfonamides is indicated if the

is at all severe

### EPISTAXIS

Epistaxis occurring spontaneously is almost invariably due to rupture of small superficial vessels of the septum overlying the inferior anterior portion of the septal cartilage These are often so near the nostril that first aid may consist only of grasping the nose and compressing it until the bleeding stops The bleeding vessel is destroyed by touching it with a chromic acid head or the actual cautery If the hemorrhage obscures the bleeding point it is advisable to insert *lightly* into the nostril a cotton pledget moistened with epinephrine (1:1000 solution) for a few minutes Forebore picking may only widen the tear and increase the bleeding It should be resorted to only for a severe hemorrhage in which case anterior packs and postnasal plugs should be inserted

If hemorrhage however scant cannot be completely and permanently controlled one of the following conditions should be suspected adenoids vascular hepatic and renal disorders purpura hemophilia leucic end arteritis neoplasms exanthemas The existence of vicarious menstruation as such is extremely doubtful although women subject to no bleed from other causes are apt to bleed during or just prior to the menstrual period

ARTHUR W. PROFTZ

### INFECTIONS OF THE NASAL ACCESSORY SINUSES

**Etiology**—The etiology of inflammatory disease of the nasal sinuses is embraced to a certain extent in those conditions which interfere with the drainage and ventilation of the cavities The obstructive lesion may be a deflected septum an enlarged or cystic middle turbinate a nasal polyp or some other nasal tumor a foreign object or enlarged adenoids

The sinuses may become infected even when the drainage and ventilation are normal if the body resistance is unduly lowered and there is a tonsillar or nasopharyngeal infection Patients suffering from an allergic rhinitis frequently have a secondary sinusitis The maxillary antrum may become involved from caries of the root of a tooth located beneath the floor of the antrum

**Pathology**—The pathologic changes

which occur in the mucous membrane and bony walls of the sinuses during the course of an infection are the same as would occur in any mucus-lined cavity. These changes may be described as acute congestive, acute suppurative, chronic suppurative and chronic hyperplastic. Chronic suppurative changes may be (a) edematous, (b) granular or infiltrating, (c) fibrous or (d) a mixture of any or all of these. Connective tissue changes are common with much thickening of the subepithelial layer. Polypi which may occur in any of the sinuses are more frequently found in the maxillary or ethmoid sinuses and would be classified as a chronic hyperplastic form of sinusitis. The hyperplastic form of sinusitis is usually secondary to an allergic rhinitis. Ulceration of the mucosa with involvement of the underlying bone takes place particularly in the chronic form of sinusitis.

**Symptoms and Diagnosis of Sinus Infections.**—Pain and headache referable to the region of the involved sinus are usually present, particularly when the frontal or maxillary sinuses are acutely involved. In acute ethmoiditis the discomfort may be described as a sense of fullness or pressure between or above the eyes. In acute sphenoiditis the headache may be vaguely deep-seated in the head, or the pain may be referred to the occipital or frontal regions. Acute frontal sinus pain is usually of the periodic type, that is, it may start in the morning and leave in the afternoon permitting the rest of the day and the night to be spent in comparative comfort. In chronic sinusitis there is usually an absence of pain; however, headache may be complained of occasionally but may not be referred to the affected sinus except during an acute exacerbation.

**Tenderness and pain on pressure** over the involved sinus is usually present in the acute form but as a rule is not found in the chronic form.

**Redness and swelling** may be present over any of the acutely involved sinuses that are contiguous to the skin. These symptoms are frequently present at the inner angle of the orbit in acute ethmoiditis in infants and children. Edema may be present without other signs of inflammation.

**Nasal Discharge.**—The presence of pus or

mucopus in the nasal chambers is usually significant of an infection within one or more of the sinuses. Pus in the middle meatus signifies involvement of the frontal, anterior ethmoid or maxillary sinus. Pus which emerges above the middle turbinate is suggestive of posterior ethmoid or sphenoid involvement. Pus may not be present in hyperplastic sinusitis.

In chronic sinusitis or in mild acute sinusitis the volume of discharge may be so slight as to produce only a postnasal dis-



Fig. 439.—Transillumination of the antrum. The patient's right side is normal; i. e., the pupillary reflex and crescent of light are present. The left side is diseased.\*

charge. The patients frequently call this a "dropping in the throat." The movement of the cilia of the nasal mucosa normally propels the secretions toward the posterior nares.

Transillumination affords valuable information as to the condition of the maxillary and frontal sinuses but none in regard to the sphenoid and ethmoid sinuses.

In transillumination of the maxillary antrum (Fig. 439), a Freer-Jackson transil-

\* Hollenger: Diseases of the Nose, Throat and Ear, Lea & Febiger Publishers.

luminator is placed in the mouth (in a dark room) with the lips closed. If the antrum is normal three signs will be noted: (1) The infraorbital crescent of light corresponding roughly to the lower portion of the lower eyelid will be seen. (2) The pupil of the eye will appear red. (3) The patient will perceive a sense of light when the eyes are closed. If the red pupillary reflex and the crescent of light are absent the antrum is probably affected. However, a thickened mucosa from a former infection, tumor formation or thick bones may obstruct the passage of light. A dental lamp may be placed also above the infraorbital ridge just below the eyeball and the glow of light looked for in the roof of the mouth.

Transillumination of the frontal sinus is accomplished by placing a hooded light under the floor of the frontal sinus at the upper and inner angle of the orbit and comparing the two sides. Variations in the amount of transillumination obtained will depend on any pathologic condition present, the size of the sinuses and the thickness of the bones through which the light must pass.

*Röntgenography* of the sinuses will give suggestive evidence as to the size and shape of the sinuses and of the absence or presence of any pathologic condition. A diagnosis should not be made from the films alone but when correlated with the clinical examination a reasonably accurate opinion may be formulated. The injection of iodized oil into the various sinuses followed by roentgenography gives valuable supplementary information, particularly in regard to the thickness of the sinus mucosa, polypoid degeneration and tumor formation.

**Complications of Sinusitis**—Extension of the infection from the sinuses to other parts of the body may occur: (1) by a thrombophlebitis of the perforating veins; (2) by way of a dehiscence through the sinus wall; (3) by direct extension through an ulcerating or necrotic area of the sinus wall; and (4) through the vascular channels in the form of bacteremia.

*Optic neuritis and retrobulbar neuritis* and other inflammatory diseases of the eye and adnexa are occasionally due to sinusitis, particularly when there is involvement of the sphenoid and ethmoid sinuses. The optic nerve may be involved by direct extension

of the inflammation by vascular congestion or by pressure on the optic nerve produced by osteitis or periostitis. In addition to these direct involvements, loss of vision as a result of sinusitis may be due to toxemia or bacteremia as seen when the sinus acts as a focus of infection. Hyperplastic sinusitis is not in itself a direct cause but as a predisposing factor it is of much importance. Multiple sclerosis is the most important cause of retrobulbar neuritis and should be excluded before operative intervention is undertaken on the sinuses.

*Orbital Cellulitis and Abscess from Sinusitis*—Infections of the ethmoid and maxillary sinuses are the most frequent causes of orbital cellulitis and orbital abscess. This is especially true during childhood when most of these orbital infections are seen. In children certain anatomical factors may be present which enhance the development of orbital complications, such as congenital dehiscences along the ethmomaxillary suture in the lamina papyracea or in the orbital wall of the maxilla. Another factor is the more profuse development of the vascular system in children, thereby facilitating the entrance of infection from the sinuses into the orbit as a thrombophlebitic process. Infection may gain entrance into the orbital cavity also by perforation of the bony sinus wall. The pus in some cases does not perforate into the orbital cavity but may be guided anteriorly by the periorbital to the eyelids where it may rupture spontaneously. The pus may also burrow along the periorbital to the sheath of the optic nerve and result in intracranial involvement. An extension of thrombophlebitis of the orbital vein into the cavernous sinus will result in cavernous sinus thrombosis.

The symptoms of these orbital infections secondary to sinusitis are increasing edema of the eyelids with or without chemosis and limited extraocular movements. Proptosis may be present either with or without the formation of an abscess. Changes in the fundus may be present in some cases.

Conservative treatment including use of the sulfonamides as indicated, hot compresses, tampons or sprays of ephedrine and mild suction will cure most cases of orbital cellulitis. Operative intervention is necessary in some cases if pus is thought to be

present or if the child's condition is becoming progressively worse (see paragraph on the external drainage of the ethmoid)

*Osteomyelitis Secondary to Sinusitis*—This complication is usually due to the *Staphylococcus aureus*. The streptococcus has been reported in a few cases and the pneumococcus rarely. About half the reported cases are found in adolescents and young adults. The spread of the infection is usually by hematogenous metastasis especially as thrombophlebitis of the venous system into the bones of the calvarium through the anastomosing diploetic veins on the under surface of the cranium or the frontal sinus but may be directly upward through the diploe to the vault of the skull. Isolated areas of infection may be found in various portions of the skull. The outer table of the skull is usually the first to break down with the formation of a subperiosteal abscess. Intracranial involvement may result from a breaking down of the inner table. The symptoms are those of a low grade sepsis and the appearance of the soft doughy swellings (Pott's puffy tumors) over the vault of the skull. The diagnosis is established by means of roentgenograms.

Penicillin (when available) should be given in adequate amounts intravenously, intramuscularly or topically. The sulfonamides especially sulfathiazole should be tried being given by mouth as well as applied locally in the form of powder to the exposed areas.

In the acute and rapidly spreading type of osteomyelitis all methods of treatment may fail. In the slowly developing and more or less chronic cases probably the best treatment is wide resection of the affected areas.

Acute osteomyelitis of the superior maxilla in infants is occasionally seen. Some cases appear to be secondary to a buccal infection others may be due to a maxillary sinusitis.

*Treatment of Sinus Infections*—The local treatment of sinus infections consists in establishing free drainage and ventilation of the sinuses. Instilling or spraying ephedrine or placing tampons of ephedrine in the region of the middle turbinate gives temporary relief. Mild suction cautiously applied is of benefit in many cases especially after the first stage of acute congestion is over. Proetz's displacement technic in which

intermittent negative pressure is used to fill and irrigate the sinuses especially the posterior ethmoids and sphenoids with a 0.25 per cent ephedrine solution is a helpful therapeutic procedure in obstinate cases. The technic may be used also as a diagnostic measure radiopaque oil being injected into the sinuses and the emptying time determined by means of subsequent roentgenograms. Some form of heat is of great comfort during the painful stage. General supportive and symptomatic medication should be given as required. In acute sinusitis with fever chemotherapy will be of decided benefit in most instances. Chemotherapy is seldom required in chronic sinusitis except during acute exacerbations.

*Irrigation of the Sinuses*—Irrigation of the maxillary sinus is of decided benefit in the acute stage after the febrile stage has passed. This may be accomplished through the natural ostium in a large majority of cases by means of Pierce's antrum cannula. If marked inflammation in the region of the middle turbinate is present if force is required to insert the cannula beneath the middle turbinate or if the maxillary sinusitis is accompanied by a frontal sinusitis it is the writer's practice to gain entrance to the antrum beneath the inferior turbinate by puncturing the nasal wall with a suitable antrum trocar. Irrigating with a saline or a 2.5 to 5.0 per cent suspension of one of the sulfonamides in a saline solution two or three times a week is of decided benefit.

Irrigations of the frontal sinus may be performed through the frontonasal duct except in those cases in which an obstruction exists such as an enlarged middle turbinate or a deflected septum. However the necessity for irrigating the frontal sinus is not so frequently indicated as in the case of the maxillary antrum because of the dependent drainage of the frontal sinus.

Irrigation of the sphenoid sinus is practiced both as a diagnostic measure and as a therapeutic means of relief. If an obstruction is present it may be necessary to remove it by some surgical procedure before the irrigations can be effected. Irrigations of the sphenoid sinus are usually given through the natural ostium but in some instances perforation of the anterior sphenoidal wall is necessary.

Irrigation of the ethmoid sinus is not possible except by Proetz's displacement method however a somewhat similar result is obtained by placing tampons of a mild colloid silver in the middle meatus and leaving them in place for twenty or thirty minutes. The hygroscopic and mild antiseptic action of the silver salt produces a free outpouring of the nasal secretions which is of decided benefit in cases of subacute or chronic ethmoiditis.

The surgical treatment of sinus infections consists in the removal of any existing obstructive lesions and in some form of intranasal or extranasal surgical procedure.

**Removal of Obstructing Lesions**—Obstructing lesions which necessitate removal are enlarged cystic or impacted middle turbinates, high deflections of the nasal septum, nasal polypi or other nasal tumors which may obstruct the normal sinus drainage, foreign objects within the nasal cavities and enlarged adenoids. As the correction of these lesions is discussed elsewhere in this volume further consideration will not be given here except to state that in many cases of sinusitis a satisfactory recovery will follow the correction of the obstructions.

**Surgery of the Maxillary Sinus**—*Removal of the Nasoantral Wall (Antrum Window)*—In many cases of subacute or chronic maxillary sinusitis favorable results will follow the intranasal removal of the nasoantral wall. After local anesthesia is established the nasoantral wall is punctured in its central portion by means of a Good or Thompson antrum trocar rasp. The same rasp is used in enlarging the opening to a sufficient size to permit the introduction of the Wagner or some similar type of biting forceps. Care should be exercised to avoid injuring the lacrimal canal which opens beneath the anterior end of the inferior turbinate. If the bony floor or other portions of the maxillary sinus are carious from dental infection a properly bent curette may be introduced through the nasoantral opening and the involved portions gently curetted. Packing is necessary only to control excessive bleeding.

**The Caldwell-Luc Operation**—In some instances of chronic maxillary sinusitis with extensive polypoid cystic or hyperplastic changes in the mucous membrane it is ne-

cessary to supplement the intranasal removal of the nasoantral wall with an additional opening through the canine fossa. This external opening which is made under the upper lip through the canine fossa permits direct inspection of the sinus and facilitates the removal of all or only the diseased portions of the mucosa. The periosteum is elevated over the canine fossa and retracted. The anterior bony wall is penetrated by means of a gouge and mallet. The opening is enlarged with the gouge and rongeur forceps. The cavity is explored and the diseased mucosa particularly over the floor is elevated and removed. Packing is required only for excessive bleeding.

**Surgery of the Frontal and Ethmoid Sinuses**—*Intranasal Drainage of the Frontal or Ethmoid Sinuses*—In those cases of chronic frontal or ethmoid sinusitis in which local treatment and the removal of any obstructive lesions have not effected a cure or an amelioration of the symptoms some form of intranasal surgical drainage may be indicated particularly if the patient shows signs of sepsis or has frequent pains or headaches. A roentgenologic study of the sinuses should be made to determine the dimensions and pathologic condition present before any surgical procedure is instituted.

Some type of operation is described by Moshé is frequently employed. This combines the removal of all or in some cases the anterior portion of the ethmoid cells together with the enlargement of the frontal ostium.

**External Drainage of the Frontal Sinus**—In a few cases of frontal sinusitis with external fistula, intracranial or orbital complications or excessive bone necrosis with unusual or extensive development with orbital extensions or with infected ethmoid cell extending over the roof of the orbit some type of external drainage may be required. The simplest of these external operations consist in removal of the anterior wall with external drainage. If necessary the lining mucosa is removed. Usually some disfigurement results. Lynch's frontoethmoid operation is perhaps the safest external operation to use as entrance to the frontal sinus is through the floor thus minimizing the danger of extension of osteomyelitis to the frontal bone. Furthermore less disfigurement results. In the Hajek-Luc operation the anterior wall

of the frontal sinus is removed septums if present are broken down and the diseased mucosa curetted. The frontonasal canal is enlarged through the floor of the frontal sinus and the anterior ethmoid cells are removed so as to establish as free drainage from the frontal sinus as possible. In rare instances a radical external approach to the combined frontal ethmoid and sphenoid sinuses is indicated.

*External Drainage of the Ethmoid*—Frequently in a case of orbital abscess or of an ethmoid fistula opening near the inner angle of the orbit it is advisable to enter the ethmoid labyrinth by an external route. An incision is made through or just below the inner portion of the eyebrow extending around the inner canthus to the lower portion of the medial orbital wall. Access to the labyrinth is obtained through the naso-orbital wall and the cells are curetted through this opening. The orbital contents should be investigated and pus drained if present. External drainage is maintained until the discharge ceases.

*Surgery of the Sphenoid Sinus—Removal of the Interior Sphenoid Wall*—Drainage of the sphenoid sinus consists in removing the anterior wall. Local anesthesia is usually sufficient. As a rule the preliminary removal of the middle turbinate is necessary to obtain room for working when the intranasal method is used. A sphenoid punch forceps is inserted through the sphenoidal ostium and the opening enlarged in a downward and outward direction. If the lining mucosa is curetted great care should be taken to avoid injuring the numerous nerves and vessels in close proximity to the mucosa. Dehiscences in the bone should be watched for assiduously.

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#### SURGERY OF THE EAR

**Congenital Deformities**—The most common congenital deformities are *microtia* in which the ear is very small *macrotia* in which there is a large auricle with sometimes an accessory projection *lop ears* which protrude at a right angle to the skull excessive enlargement of the lobe complete or partial stenosis of the external auditory meatus and complete absence of the external ear.

**Injuries**—Many types of injuries to the external ear occur both in war and in civil life. In the latter automobile accidents play the leading role. To remedy defects plastic operations may be attempted and if complete loss of an auricle occurs a prosthesis may be held in place by spectacles.

**Othematoma**—A suffusion of blood between the cartilage and the perichondrium due to trauma is called an othematoma. It is frequently seen in boxers. In the acute stage the fluid blood may be aspirated and pressure applied to prevent further bleeding. Great care must be exercised to prevent infection. If a clot has formed an incision should be made the clot turned out and pressure applied. If this is neglected great permanent deformity frequently results. If infection takes place between the cartilage and the perichondrium the abscess should be drained and the cavity treated antiseptically. Otherwise necrosis of cartilage soon takes place and fibrosis occurs with the resulting cauliflower ear.

**Neoplasms**—A number of benign tumors such as fibromas osteomas and occasionally chondromas may occur usually in the external canal. Of the malignant tumors epithelioma is the most common but endothelioma and sarcoma may be encountered. Epithelioma of the auricle is often not highly malignant in its course unless invasion of the adjacent structures occurs. The treatment consists in operative removal or still better in many instances the application of roentgen rays radium or surgical diathermy.

**Foreign Bodies in the Ear**—Foreign bodies of all kinds may be inserted into the

external auditory canal especially by children and the insane. If they are forced beyond the isthmus of the canal their removal is difficult. Some substances tend to swell when moisture enters the canal while others by pressure cause erosion of the skin of the meatus or perforation of the drum membrane. The removal of foreign bodies as well as inspissated cerumen must be undertaken with great care lest by use of instruments injury to the canal or perforation of the drum membrane results with consequent infection of the middle ear. A stream of warm water carefully directed toward the superior wall of the canal will sometimes dislodge a foreign body and cerumen can almost always be removed in this manner. It may be softened by means of glycerin or oil before the syringing. At times the substance such as a pebble is in contact with the drum membrane so that a retroauricular incision must be made in order to extract it. Incisions should first be made quiet by the use of chloroform vapor alcohol oil or kerosene and then removed with forceps or by syringing.

### INFECTION OF THE EXTERNAL EAR

Otitis externa may be either circumscribed in the form of furuncles or diffuse often as a result of infection with *B. pyocyaneus*. The chief symptom is pain in and around the external canal with three special points of tenderness elicited by (1) pressure on the tragus (2) manipulation of the auricle and (3) pressure on the infra-auricular gland.

**Treatment**—For the circumscribed form of otitis heat should be applied the canal packed with ichthyol yellow oxide of mercury ointment or aluminum acetate and the furuncle incised only when fully developed. For the diffuse form oxidizing agents such as hydrogen peroxide potassium permanganate etc. should be avoided as *B. pyocyaneus* is oxygen-bile. Packs of 3 or 5 per cent silver nitrate should be used. In either form pain may be relieved by from 5 to 10 per cent phenolglycerin applied to the external auditory canal. Sedatives are often necessary. In the diffuse form surgical intervention is contraindicated. Vaccines are often found to be helpful in preventing recurrence.

### INFECTION OF THE MIDDLE EAR

**Acute Otitis Media**—*Etiology*—The middle ear is usually involved by way of the eustachian tube following infection of the nose nasopharynx or pharynx. Occasionally infection occurs via the external auditory canal either as the result of perforation of the drum membrane by a foreign body or by entrance of water or some other substance through an old perforation. Rarely is the infection of hematogenous origin from a distant focus.

The *symptoms* are pain in the ear (sometimes accompanied by headache) fever and a diminution in hearing.

**Treatment**—For the relief of pain from 5 to 10 per cent phenolglycerin heat and sedatives are used.

**Paracentesis**—For relief of pressure and retention myringotomy (paracentesis of the drum membrane) is necessary the indications being:

I Light symptoms (1) pains in the ear which defy other remedial measures (2) reduction in hearing (the whispered voice heard less than 1 to 2 meters away) and (3) bulging or redness of the drum membrane. If any two of these symptoms are present myringotomy is required.

II Important or grave symptoms. The light symptoms plus (1) fever (2) headache and (3) mastoid tenderness. If any one of these additional symptoms is present myringotomy should be performed. The drum membrane should be incised at the point of greatest bulging but the most favorable location is in the posteroinferior or the anteroinferior quadrant.

**Complications of Acute Otitis Media**—The most often observed complications are acute mastoiditis lateral sinus phlebitis or thrombosis petrositis sepsis and meningitis.

*Acute mastoiditis* is usually due to extension of the infection to the mastoid antrum and other mastoid cells. There are four types of mastoid process (1) the pneumatic in which the cells or air spaces (lined with mucous membrane) extend from the antrum to the tip and often to the posterior border of the mastoid (2) the diploic in which there are diploic spaces (marrow spaces) but no pneumatic cells (3) the mixed type in which some parts are pneu-

matized and others are diploic, and (4) the type in which the mastoid process is composed wholly or in large part, of hard com-

middle ear or mastoid infection. The symptoms of pain and tenderness may be present within a few days after the onset of the

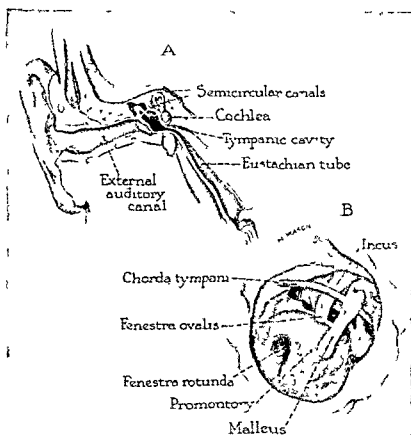


Fig 440—Diagram showing the structures of the middle ear

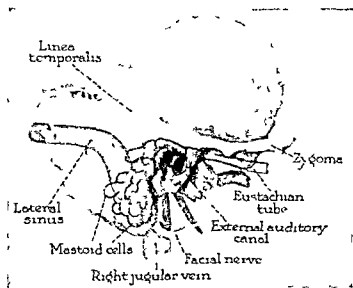


Fig 441—Diagram showing relationship of important structures in the region of the middle ear

pact bone ("sclerotic" type) with few if any, air or marrow spaces. This type is often the end result of repeated or long-continued

acute otitis media, but this does not mean that changes requiring surgical intervention are necessarily developing. Decalcification



of the bony trabeculae usually requires from one to three weeks in certain types of virulent infection the breaking down of these trabeculae may occur much earlier.

The *symptoms* vary greatly in number and severity. Usually there is some *pain* in the mastoid process. When the infection reaches the outer cortex and involves the periosteum there is tenderness. This is likely to appear early and to be well marked in childhood when the cortex is thin and conversely it is often absent in advanced age when the cortex is thick and hard. The usual points of tenderness are (1) the region of the mastoid antrum (2) the tip especially if there is a large terminal cell and (3) the posterior border of the mastoid process. Varying degrees of *fever* may be present especially in children but in adults it is rarely high or of an intermittent character unless the inflammatory process involves the vicinity of the lateral sinus or other veins. *Chills* especially when followed by a sudden high rise in temperature with a rather abrupt drop are usually significant of a pathologic condition in or near the lateral sinus. In children however the same symptoms may be due to involvement of small veins present throughout the mastoid process and not the lateral sinus itself. When the inflammatory condition affects the cortex and periosteum some *swelling* or infiltration is usually noted. *Edema* is often present and may appear at an early stage in young children. It is at times due not to the involvement of the mastoid itself but to a furuncle on the posterior wall of the external auditory canal. *Sinking* or *sagging* of the posterosuperior wall of the bony portion of the external auditory canal is usually considered an indication for a simple mastoid operation. If fistula of the mastoid cortex occurs the escaping pus elevates the periosteum and fluctuation is present. It must be remembered that in infants with an open petrosquamosal suture a *subperiosteal abscess* may develop without destruction of bone.

*Treatment*—The opening of the mastoid antrum (antrotomy) and the removal of all infected or diseased bone is the surgical treatment. The proper administration of the sulfonamides has greatly reduced the incidence of mastoiditis.

Indications for *simple mastoidectomy*

(*antrotomy*) vary with different otologists but include profuse purulent discharge continuing for from three to six weeks persistence of fever or pain from the onset of the disease or recurrence after subsidence in the first week sagging of the bony external canal wall swelling of the soft tissue over the mastoid subperiosteal abscess marked diminution in hearing paralysis of the facial nerve and any pyemic or cerebral symptoms not due to infection elsewhere.

*Technic of Antrotomy* General anesthesia is usually employed but local anesthesia may be used in severe cases of diabetes tuberculosis etc. An incision is made about  $\frac{3}{4}$  inch posterior and parallel to the insertion of the auricle and the periosteum is elevated. With a gouge or an electrically driven burr the cortex is removed and the antrum located. All softened bone and granulations are removed not only in the antral region but in the zygomatic root the mastoid tip and behind the lateral sinus. If the bone covering the lateral sinus or dura is softened it should be removed. Even if this bone is apparently normal the sinus should be uncovered and investigated if there have been chills intermittent fever or any other symptoms indicating the possibility of an infection in or about the lateral sinus. After all pathologic tissues have been removed the wound is lightly packed with plain gauze iodoform gauze a cigarette or gauze saturated with 5 per cent sulfanilazole ointment or the wound is dusted or even loosely filled with one of the Monamides powders and then closed with sutures or clips except for a small space at the lowest point through which the packing projects. Most otologists prefer to remove all cell-bearing areas whether or not they are objectively infected at the time and the operation is not considered complete until this has been done.

### LABYRINTHITIS

*Etiology*—Primary labyrinthitis is due to trauma etc. while secondary suppurative labyrinthitis is due to infections of the inner ear via the middle ear during either acute or chronic otitis media. Usually the cochlea and vestibule are both involved. Clinical varieties include (1) circumscribed (2) serous and (3) diffuse purulent labyrinthitis.

*Symptoms*—In circumscribed labyrinthitis there is often the fistula symptom and if the stage of irritation is present there is nystagmus to the diseased side. In serous labyrinthitis there is usually nystagmus to the diseased side marked diminution in hearing and vertigo. In diffuse suppurative labyrinthitis there is always complete loss of hearing in the affected ear complete ab-

sence of vestibular reactions nystagmus to the well side marked vertigo fever (usually) and development of meningitis (often)

**Treatment**—For circumscribed labyrinthitis which occurs usually in chronic otitis media radical mastoidectomy is performed without disturbing the fistula in the semi-circular canal. For serous labyrinthitis complete rest but usually no operation is needed aside from a myringotomy or simple mastoidectomy when other indications for these operations are present. In diffuse suppurative labyrinthitis if there is high fever or any sign of meningeal irritation radical mastoidectomy and opening of the labyrinth are necessary. There are various types of labyrinth operations such as the Neumann Hinsberg etc. The cochlear and vestibular portions of the inner ear are opened to effect drainage. Unless symptoms of imminent intracranial involvement are present labyrinth drainage is most safely done during the latent period that follows the subsidence of the acute symptoms.

#### CHRONIC OTITIS MEDIA

**Etiology**—A case of acute otitis media may become chronic because of (1) some pathologic conditions in the nose pharynx or nasopharynx such as sinus infection adenoids or infected tonsils (2) disease of the eustachian (tympanic) (3) disease of the mastoid cells (not involvement in the early stage of acute otitis media which usually subsides) (4) disease in the petrous pyramid such as parabyrinthitis (5) systemic disease such as tuberculosis (6) mixed infections of the middle ear and (7) severe acute infectious diseases such as scarlatina measles diphtheria etc.

**Symptoms**—The most common symptom is the purulent secretion which is often fetid because of the necrosis of bone. Sometimes the ear is dry except when acute exacerbations occur. Hearing is usually impaired especially for the low tones. Pain is usually present only at the time of the acute exacerbation or when there is necrosis of the bone which is in proximity to the dura. Cholesteatoma is present in many cases with marginal perforations.

With central perforation involvement of bone and likewise intracranial complications are rare. In this type of case there is often

mucopurulent secretion due to infection via the eustachian tube which rarely calls for surgical intervention. Marginal perforation involves the bone often causes serious complications and is the type that usually requires operation.

**Treatment**—(A) *Non Surgical*—If the secretion is mucopurulent suggesting involvement of the eustachian tube the nasopharynx should be treated the adenoids removed etc. The use of 50 or 75 per cent alcohol or pure ether in the middle ear is often of some benefit. Granulations may be cauterized with trichloroacetic acid chromic acid or silver nitrate or they may be removed surgically. With perforation in Shrapnell's membrane and involvement of the attic irrigation with dilute alcohol is indicated but if there is no improvement after a reasonable period radical mastoidectomy must be performed. If a large perforation is present with only a small amount of secretion boracic or iodine powder should be insufflated. Whenever a perforation is present it should be remembered that no water should at any time be allowed to enter the ear because of the danger (1) of reinfection of the middle ear or (2) of a caloric reaction with consequent vertigo.

(B) *Surgical Treatment*—(1) *Ossiculectomy* is occasionally performed in cases of necrosis of the ossicles accompanied by moderate suppuration and in properly selected cases this obviates the necessity for a more radical procedure. Later (2) *Radical mastoidectomy* is necessary when the following are noted (a) marginal perforation especially in the posterosuperior quadrant of the drum membrane with necrosis of bone (b) cholesteatoma (c) a persistent fetid purulent discharge (d) repeated acute exacerbations of a chronic otitis media and (e) intracranial complications.

**Technic of Radical Mastoidectomy**—The theory of radical operation in chronic otitis media is to eliminate all areas of infection in the middle ear and mastoid process and to convert the middle ear mastoid antrum and cells and the external auditory canal into one continuous cavity. An incision is made about 1 or 2½ inch posterior and parallel to the insertion of the auricle. The periosteum is reflected not only over the mastoid process but over the posterior and upper wall of the bony external canal. The cortex is entered either with a gouge or with an electrically driven burr and the antrum located great care being taken to avoid the

external semicircular canal and the facial nerve which lies just below it and above the oval window. The so-called "bridge" (the outer half of the inner end of the posterior wall of the bony external auditory canal) is removed, converting the middle ear into the atrium and the external auditory canal into one cavity. The so-called "facial spur" (the posterior bony canal wall) is cautiously leveled down as far as possible without injury to the facial nerve. All granulations and necrotic bone are carefully removed from the antrum, attic and middle ear. Great caution must be observed in curetting the latter to avoid injury to the footplate of the stapes for fear of causing acute labyrinthitis and consequent meningitis. To prevent reflections of the middle ear by way of the eustachian tube its tympanic end should be curetted to produce closure, but injury to the internal carotid artery, which lies in close proximity, must be avoided. After careful inspection of the whole cavity a plastic procedure is done on the membranous portion of the posterior wall of the external auditory meatus. Sulfathiazole ointment packing is inserted via the canal after the wound has been dusted with one of the sulfonamide powders or the entire cavity may be loosely filled with the powder and only enough gauze packing used to keep the plastic flaps in position. Then the retroauricular wound is sutured. If the lateral sinus lies far forward so that the approach to the antrum is very difficult or impossible by the usual route the Stacke operation, which seeks the antrum by way of the external auditory canal, must be employed.

The operative results are judged from three standpoints: (1) Secretion. If the whole cavity is ultimately lined with epidermis the cavity will be dry in a considerable percentage of cases; however (as high as 30 per cent) some secretion persists. (2) Hearing. If the impairment of hearing before operation is very great much improvement rarely occurs; sometimes the hearing is even worse after operation. (3) Prevention of intracranial complications. If the operation is properly performed this purpose is usually achieved.

**Complications of chronic otitis media** usually occur at the time of acute exacerbations but they may develop during acute otitis media without any previous attack.

**Lateral Sinus Thrombosis**—Involvement of the lateral sinus may appear as a perisinus abscess, phlebitis or actual thrombosis within the lumen.

**Symptoms**—(1) A sudden high rise in temperature accompanied by a chill and then an abrupt drop to normal or subnormal. (2) Marked leukocytosis especially an increase in the polymorphonuclear leukocytes. (3) Edema over the posterior portion of the mastoid process if the emissary vein

is involved and (4) embolism which often occurs and affects the joints, heart muscle, lungs or other parts of the body.

**Diagnosis**—Pneumonia and other causes of pyemia as well as malaria must be excluded. The Tobey-Ayer test is often of value in determining whether or not occlusion is present. It is also of value in bilateral mastoiditis as it shows which side is thrombosed.

**Treatment**—If thrombosis is suspected a simple mastoidectomy is performed if this has not already been done and the lateral sinus exposed at its sigmoid portion. If investigation confirms the diagnosis the internal jugular vein should now be ligated and cut between two ligatures. If the vein itself is infected it should be excised even to the jugular bulb. Returning now to the lateral sinus the latter is incised and the clot removed. If free bleeding is obtained from both ends the wound is merely picked. If bleeding does not occur from the upper end it should be exposed until free bleeding is obtained and then picked, gauze being inserted between the bone and the sinus.

**Brain Abscess**—Abscesses occur usually in the temporo-sphenoidal lobe or in the cerebellum. (See section on Brain Abscess.)

**Otitic Meningitis**—There may be diffuse suppurative leptomeningitis, circumscribed suppurative leptomeningitis or serous meningitis. Recently the sulfonamide derivatives have been employed in streptococcal and pneumococcal infections such as lateral sinus thrombosis and meningitis. This subject is treated in the section on suppurative meningitis. Any treatment of this condition if otitic in origin is incomplete unless the focus of infection is first removed. This means a complete simple mastoidectomy with exposure of the dura of both the middle and posterior fossae. Sometime in this way an extradural abscess will be discovered. Some otologists of experience also advocate dural incision. Under this plan with adequate chemotherapy and serotherapy plus frequent or continuous cerebrospinal drainage by lumbar puncture the mortality for otitic meningitis (diffuse suppurative) has been reduced in recent years from nearly 100 per cent to well below 50 per cent.

**Petrositis**—The structure of the petrous pyramid corresponds to that of the mastoid

process and therefore may be pneumatic diploia, mixed or sclerotic in type. Infection may enter by cellular extension from the middle ear or mastoid cells either posterior superior or inferior to the labyrinth or anteriorly between the cochlea and the internal carotid artery. The pathologic process may be either empyema in a cell or cells or osteomyelitis.

In the presence of middle ear or mastoid infection either acute or chronic the symptoms are pain on the side of the lesion frequently referred to the area supplied by the ophthalmic division of the fifth nerve paralysis of the sixth nerve (the Gradenigo triad) a low continued fever a profuse middle ear discharge and roentgenologic evidence of decalcification of the petrosa.

A simple or radical mastoidectomy, depending on the chronicity of the case will afford satisfactory drainage in many instances. At the time of operation fistulous tracts leading to the pyramid should be carefully sought for and, if found, curetted. If these measures fail the petrous pyramid may be attacked directly.

The most satisfactory procedure is some modification of Eggleston's technique. After a simple mastoidectomy has been done the dura is freely exposed by removal with gouge or rongeur of the tegmen mastoideum, the squama and the posterior portion of the zygoma. Ventriculopuncture relieves brain tension so that the brain can be retracted and the anterior and posterior surfaces of the pyramid exposed nearly to the internal auditory meatus. If an extradural abscess is discovered it may be drained or the interior of the pyramid may be opened with a curette.

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Revised by GEORGE M. COATES

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## THE THROAT

**Anatomy.**—The region commonly known as the throat is bounded anteriorly by the base of the tongue laterally and posteriorly by the pharyngeal walls superiorly by the nasopharyngeal space and inferiorly by the hypopharynx. From a surgical standpoint, this area is important primarily because of the fact that it contains in a more or less symmetrical arrangement definite masses of lymphoid tissue characterized as in other parts of the body by lymph follicles embedded in connective tissue and particularly in the throat covered by stratified epithelium which dips down into deep crypts and pockets. This arrangement of lymphoid tissue in the throat known commonly as Waldeyer's ring is distributed as follows. On each side of the base of the tongue are two masses of lymphoid tissue known as the lingual tonsil on each lateral wall lying against the superior constrictor muscles of the pharynx and slung between the palatoglossus and palatopharyngeus muscles (the so-called anterior and posterior pillars) is the largest of these lymphoid elements the faucial tonsil. A mass of tissue known as the adenoid lies just at the base of the nasal septum and covers the upper half of that portion of the posterior pharyngeal wall which is shut off from view by the soft palate. In addition there are smaller and irregularly shaped and sized masses of lymphoid tissue scattered on the lower posterior pharyngeal wall and on the posterior surface and edges of the palatopharyngeus muscle. These masses of lymphoid tissue are found in all proportions. Their fundamental importance lies in the fact that situated at the very gateway to the upper and lower respiratory tract they constitute one of the most important sources of focal infection in the entire body. Bacteria becoming lodged in the depths of the epithelial crypts break through into the deeper structures and by vascular or lymphatic transfer are readily borne to other parts of the body. In addition all varieties of local inflammation are manifested in this lymphatic ring thereby giving rise according to the type of invading micro-organism to a group of specific diseases. These inflammatory manifestations of infection may be acute or chronic and necessitate surgical or medical therapy.

#### PATHOLOGIC CONDITIONS

**Acute Tonsillitis.**—Primarily because of its size and complex lymphatic and vascular connections the faucial tonsil is representative of the rest of the ring in its reaction to infection. Hence, so-called acute tonsillitis stands for acute infection with any of the common bacterial invaders in the lingual tonsil the adenoid or the pharyngeal nodules. It is characterized by the cardinal signs of inflammation—redness pain (particularly on swallowing) and fever. All the lymphoid structures present a characteristic appearance exemplified in the faucial tonsil by small punctate white yellow spots scattered

external semicircular canal and the facial nerve which lies just below it and above the oval window. The so-called 'bridge' (the outer half of the inner end of the posterior wall of the bony external auditory canal) is removed converting the middle ear the antrum and the external auditory canal into one cavity. The so-called facial spur (the posterior bony canal wall) is cautiously leveled down as far as possible without injury to the facial nerve. All granulations and necrotic bone are carefully removed from the antrum attic and middle ear. Great caution must be observed in curetting the latter to avoid injury to the footplate of the stapes for fear of causing acute labyrinthitis and consequent meningitis. To prevent infections of the middle ear by way of the eustachian tube its tympanic end should be curetted to produce closure but injury to the internal carotid artery which lies in close proximity must be avoided. After careful inspection of the whole cavity a plastic procedure is done on the membranous portion of the posterior wall of the external auditory meatus. Sulfathiazole ointment packing is inserted via the canal after the wound has been dusted with one of the sulfonamide powders or the entire cavity may be loosely filled with the powder and only enough gauze packing used to keep the plastic flaps in position. Then the retroauricular wound is sutured. If the lateral sinus lies far forward so that the approach to the antrum is very difficult or impossible by the usual route the Stacke operation which seeks the antrum by way of the external auditory canal must be employed.

The operative results are judged from three standpoints: (1) Secretion. If the whole cavity is ultimately lined with epidermis the cavity will be dry in a considerable percentage of cases; however (as high as 30 per cent) some secretion persists. (2) Hearing. If the impairment of hearing before operation is very great much improvement rarely occurs; sometimes the hearing is even worse after operation. (3) Prevention of intracranial complications. If the operation is properly performed this purpose is usually achieved.

**Complications of chronic otitis media** usually occur at the time of acute exacerbations but they may develop during acute otitis media without any previous attack.

**Lateral Sinus Thrombosis**—Involvement of the lateral sinus may appear as a perisinus abscess, phlebitis or actual thrombosis within the lumen.

**Symptoms**—(1) A sudden high rise in temperature accompanied by a chill and then an abrupt drop to normal or subnormal. (2) Marked leukocytosis especially an increase in the polymorphonuclear leukocytes. (3) Edema over the posterior portion of the mastoid process if the emissary vein

is involved and (4) embolism which often occurs and affects the joints, heart muscle, lungs or other parts of the body.

**Diagnosis**—Pneumonia and other causes of pyemia as well as malaria must be excluded. The Tobe-Ayer test is often of value in determining whether or not occlusion is present. It is also of value in bilateral mastoiditis as it shows which side is thrombosed.

**Treatment**—If thrombosis is suspected a simple mastoidectomy is performed if this has not already been done and the lateral sinus exposed at its sigmoid portion. If investigation confirms the diagnosis the internal jugular vein should now be ligated and cut between two ligatures. If the vein itself is infected it should be excised even to the jugular bulb. Returning now to the lateral sinus the latter is incised and the clot removed. If free bleeding is obtained from both ends the wound is merely packed. If bleeding does not occur from the upper end it should be exposed until free bleeding is obtained and then packed gauze being inserted between the bone and the sinus.

**Brain Abscess**—Abscesses occur usually in the temporosphenoidal lobe or in the cerebellum. (See section on Brain Abscess.)

**Otitic Meningitis**—There may be diffuse suppurative leptomeningitis, circumscribed suppurative leptomeningitis or serous meningitis. Recently the sulfonamide derivatives have been employed in streptococcal and pneumococcal infections such as lateral sinus thrombosis and meningitis. This subject is treated in the section on suppurative meningitis. Any treatment of this condition if otitic in origin is incomplete unless the focus of infection is first removed. This means a complete simple mastoidectomy with exposure of the dura of both the middle and posterior fossae. Sometimes in this way, an extradural abscess will be discovered. Some otologists of experience also advocate a dural incision. Under this plan with adequate chemotherapy and serotherapy plus frequent or continuous cerebrospinal drainage by lumbar puncture the mortality for otitic meningitis (diffuse suppurative) has been reduced in recent years from nearly 100 per cent to well below 50 per cent.

**Petrositis**—The structure of the petrous pyramid corresponds to that of the mastoid

process and therefore may be pneumatic, diploic, mixed or sclerotic in type. Infection may enter by cellular extension from the middle ear or mastoid cells either posterior, superior or inferior to the labyrinth, or anteriorly between the cochlea and the internal carotid artery. The pathologic process may be either empyema in a cell or cells or osteomyelitis.

In the presence of middle ear or mastoid infection, either acute or chronic, the symptoms are pain on the side of the lesion, frequently referred to the area supplied by the ophthalmic division of the fifth nerve, paralysis of the sixth nerve (the Gradenigo triad), a low, continued fever, a profuse middle ear discharge and roentgenologic evidence of decalcification of the petrous.

A simple or radical mastoidectomy, depending on the chronicity of the case will afford satisfactory drainage in many instances. At the time of operation, fistulous tracts leading to the pyramid should be carefully sought for and, if found, curetted. If these measures fail, the petrous pyramid may be attacked directly.

The most satisfactory procedure is some modification of Eggleston's technic. After a simple mastoidectomy has been done, the dura is freely exposed by removal with gouge or rongeur of the tegmen mastoidum, the squama and the posterior portion of the zygoma. Ventriculopuncture relieves brain tension so that the brain can be retracted and the anterior and posterior surfaces of the pyramid exposed nearly to the internal auditory meatus. If an extradural abscess is discovered, it may be drained or the interior of the pyramid may be opened with a curette.

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Revised by GEORGE M. COATES

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## THE THROAT

**Anatomy.**—The region commonly known as the throat is bounded anteriorly by the base of the tongue, laterally and posteriorly by the pharyngeal walls, superiorly by the nasopharyngeal space and inferiorly by the hypopharynx. From a surgical standpoint this area is important primarily because of the fact that it contains in a more or less symmetrical arrangement definite masses of lymphoid tissue characterized as in other parts of the body by lymph follicles enmeshed in connective tissue and particularly in the throat, covered by stratified epithelium which dips down into deep crypts and pockets. This arrangement of lymphoid tissue in the throat known commonly as Waldeyer's ring is distributed as follows. On each side of the base of the tongue are two masses of lymphoid tissue known as the lingual tonsil, on each lateral wall lying against the superior constrictor muscles of the pharynx and sitting between the palatoglossus and palatopharyngeus muscles (the so-called anterior and posterior pillars) is the largest of these lymphoid elements, the faucial tonsil. A median mass of tissue known as the adenoid lies just at the base of the nasal septum and covers the upper half of that portion of the posterior pharyngeal wall which is shut off from view by the soft palate. In addition there are smaller and irregularly shaped and sized masses of lymphoid tissue scattered on the lower posterior pharyngeal wall and on the posterior surface and edges of the palatopharyngeus muscle. These masses of lymphoid tissue are found in all proportions. Their fundamental importance lies in the fact that, situated at the very gateway to the upper and lower respiratory tract, they constitute one of the most important sources of focal infection in the entire body. Bacteria becoming lodged in the depths of the epithelial crypts break through into the deeper structures and by vascular or lymphatic transfer are readily borne to other parts of the body. In addition all varieties of local inflammation are manifested in this lymphatic ring thereby giving rise according to the type of invading micro-organism, to a group of specific diseases. These inflammatory manifestations of infection may be acute or chronic and necessitate surgical or medical therapy.

#### PATHOLOGIC CONDITIONS

**Acute Tonsillitis.**—Primarily because of its size and complex lymphatic and vascular connections the faucial tonsil is representative of the rest of the ring in its reaction to infection. Hence, so-called acute tonsillitis stands for acute infection, with any of the common bacterial invaders in the lingual tonsil, the adenoid or the pharyngeal nodules. It is characterized by the cardinal signs of inflammation—redness, pain (particularly on swallowing) and fever. All the lymphoid structures present a characteristic appearance exemplified in the faucial tonsil by small punctate white-yellow spots scattered

over the mucous membrane surface of the tonsil and representing epithelial crypts filled with desquamated epithelium and bacteria (follicular tonsillitis). The treatment is largely medical including forcing of fluids, rest in bed, free alkalization and the use of some preparation of salicylic acid. Hot saline irrigations are often helpful.

Within the past two years there has been an increasing disposition on the part of many general practitioners to administer some form of chemotherapy, particularly sulfadiazine in acute tonsillitis. While the condition is usually self limited chemotherapy is frequently effective in preventing secondary complications especially peritonsillar abscess.

**Diphtheria.**—In a somewhat similar way the tonsil and also other portions of the ring may become involved in a diphtheritic infection. Due to a specific infection with the diphtheria bacillus and far less common than formerly this disease must still be borne in mind as a possible explanation for the characteristic picture of a grayish white membrane with irregular shape and margin which bleeds freely on removal has a characteristic odor and contains fibrinous meshes and active organisms. The immediate symptoms and treatment are essentially medical rather than surgical. The same is true of Vincent's angina. Here the lesion is a necrosis of the epithelium with a deeper destruction of tissue; there is no true membrane to be removed and the specific spirochete and bacillus in symbiosis make the diagnosis relatively easy.

**Septic Sore Throat.**—Much more violent in its inflammatory manifestations is the so-called acute streptococcal infection of the throat which is characterized by a general diffuse fiery redness of all the mucosal surfaces not alone of the tonsil but of the adjacent pillars and pharyngeal surfaces as well. There is no true membrane but pseudo-membranous patches may be found on the tonsillar surface. There are high fever and prostration with systemic toxemia which in one specific form is either identical with or similar to scarlet fever.

Since this form of acute inflammation in the throat is often more violent and more likely to manifest systemic symptoms the administration of chemotherapy is much

more rational and appropriate than in the case of simple acute tonsillitis.

Cancer likewise does not spare the epithelial surfaces so obviously presented by the tonsil crypts. The lesions are characterized by ulceration and necrosis and as in other parts of the body are prone to progress unnoticed until beyond surgical help. While radical surgical treatment with complete extirpation of the involved area together with block dissection of the neck has had its advocates today the greater enthusiasm is for treatment with x-ray and radium.

Like any other buccal mucosa, the tonsil is subject to certain diseases which are often found in other parts of the mouth such as tuberculosis, syphilis, leukoplakia, etc. Their local treatment falls rather in the domain of dermatology than surgery.

### TONSILLECTOMY

Since Waldeyer's ring is frequently the site of a wide range of pathologic processes, laryngologic surgery has developed a procedure for the removal of two masses and frequently a third mass of this tissue—the two faucial tonsils with or without the lingual tonsils depending on their size and degree of involvement and the large central mass or adenoid. The surgical removal of these structures has become without doubt the commonest and most frequently performed operation of modern times. As such it has been productive of an untold amount of benefit to the human race and likewise through popular overenthusiasm and performance by inadequately trained operators the source of great harm and even of tragic fatality.

**Indications for Operation.**—First among the dependable indications is gross hypertrophy. Not infrequently and especially in children the faucial tonsil will be so large as practically to meet in the midline. This may be so even without previous infection, glandular enlargement or history of any acute inflammation and yet the interference with eating or breathing (in which a similarly hypertrophied adenoid is involved) will make removal of these organs imperative. The classical faces of a child in whom this symptom complex is present is well known together with its effect on the weight, general well being and mentality.

The second classical indication for removal of the tonsils and to a lesser extent the adenoids is the history of previous acute infections particularly of the follicular type. When there has been only one such infection it may be good practice to await the occurrence of another but certainly evidence of repeated attacks of tonsillitis constitutes a generally accepted indication.

Enlarged cervical glands draining the tonsillar area are accepted as pointing to these organs as the primary source of trouble and hence as warranting their removal. Particularly where these glands show evidence of tuberculosis either on dissection or incision it is likely that the tonsil harbors tuberculosis which should be eradicated.

The recurrence of attacks of otitis media is a well recognized indication for removal of the adenoids. Regarded as promoting the entrance of infection to the eustachian tubes this tissue has been removed from countless children with untold benefits in the matter of arrested and eradicated deafness, cessation of acute middle ear infections and prevention of mastoid and cerebral complications.

Beyond this local field lies a vast range of lesser indications which have been accepted or rejected by different operators according to their individual enthusiasm and the results obtained. Recurrent bronchitis and laryngitis, repeated head colds, nasal sinusitis, even pneumonia have all been thought to have been cured or their recurrence prevented by removal of tonsils and adenoids. Still more remote are those general systemic conditions such as rheumatic fever, chorea, pyelitis, nephritis and arthritis which have been enthusiastically treated by tonsillectomy on the ground that they are due to focal tonsillar infection.

*Examination*.—How then shall the conscientious surgeon decide? He must base his opinion on a careful history, a careful medical examination to exclude other conditions as a cause of the symptoms and finally and of less importance than either of the others on the local examination. The latter should consist of an inspection of the throat to determine the size and configuration of the tonsil, the injection of the pillars and the arrangement of the other lymphoid masses. The existence of cheesy deposits within the

crypts of the tonsil is often suggestive of infection but the presence of fluid pus best seen on exerting the tonsil by pressure on the anterior pillar is far more conclusive evidence of the existence of infection. Attention to the nose, the cervical glands and the ears should complete the examination.

*Operative Technique*.—Granted that operation has been recommended, how shall it be performed? In children the anesthesia of choice is ether though many competent advocates of the guillotine type of operation employ gas and oxygen alone. The greater relaxation afforded by ether anesthesia and the longer time available for careful checking of bleeding and thorough inspection of the throat make it distinctly preferable. The same is true for adults so far as general anesthesia is concerned. In many parts of the country, however, particularly the South and the West, a large proportion of the tonsillectomies are performed under local anesthesia in adults.

Probably no surgical procedure boasts of greater variety in technique than does tonsillectomy. In general, however, the various methods group themselves into two main subdivisions: (1) the method of dissection and (2) the guillotine method. In the former the peritonsillar tissues are dissected away from the tonsil by various knives or scissors and the tonsil is enucleated from its bed against the pharyngeal constrictors by passing a cold wire snare about it including its so-called capsule and leaving behind a smooth muscular aponeurosis. In the second method any one of a variety of fenestrated instruments is used through the ring of which the tonsil is pushed and held while a sharp blade is pushed down behind it severing its attachments which are held back by the surrounding ring. Hemostatic blades and various other accessories are in frequent use but the principle of dislocation of the tonsil from its bed and its severance with a blade is common to all of them. The merits claimed for the latter method are rapidity, uniformity of the preservation of surrounding tissues and lessened postoperative discomfort. There is however some risk of leaving small tonsillar fragments behind especially at the basal portion which must be removed with the snare as in dissection. In the removal of adenoids there are two



principal schools those who favor the scraping of the mass from the pharyngeal wall with a special curette and those who prefer an instrument which severs the adenoid with a flexible cutting blade and collects it in a box like container into which the end of the knife blade is fitted. By any method the work is blinder than is the case with the tonsil and great care must be taken to assure complete removal yet without inflicting injury on the deeper living tissues and blood vessels.

Like many another widely practiced operation tonsillectomy of necessity comes to be regarded by many somewhat lightly and as having no special risk. The mortality is the lowest of any surgical procedure considering the great number of operations but the occasional fatality in any non urgent and purely elective procedure only emphasizes the more tragically the importance of taking every precaution and of employing constant vigilance particularly in large clinics so that nothing shall ever go wrong in this operation. In this light the procedure is not a minor one and should never be regarded as such. In particular should the surgeon be on guard against hemorrhage within the first twelve hours which if unrecognized particularly in a child may have the most dire consequences. It should be checked at once either by suture in the case of the tonsils or by post nasal packing in the case of the adenoid. Secondary or late bleeding is usually of less significance and is far more amenable to simple measures for control.

#### PERITONSILLAR ABSCESS

In general acute tonsillar infections are self limited and the immediate acute attack subsides without incident. At times however after a period of quiescence during which recovery is apparently progressing there occurs a return of the local pain and inflammation more severe than the original affliction and accompanied by special signs and symptoms. Chief of these is a pronounced difficulty in opening the mouth the pterygoid muscles as a result of inflammatory edema being set so rigidly as to prevent the jaw from opening more than an inch. At the same time there develops a diffuse swelling near the upper pole of the tonsil involving the anterior pillar and half of

the soft palate with a characteristic fiery red and shiny edematous appearance. Fever is usually absent. This condition known as a peritonsillar abscess or quinsy sore throat is rarely seen in children is usually unilateral and is preceded by an attack of acute tonsillitis. It produces intense pain and demands free drainage as soon as there is a definite localization of pus in the loose areolar tissue of the supratonsillar fossa. Until this localization has developed, the patient should be made as comfortable as possible with sedatives external heat and hot throat irrigations since unsuccessful attempts at drainage are worse than none at all and only cause the patient added suffering. As soon as the definite localization of pus is evidenced by an elastic feeling on palpation of the involved region and the appearance of a tense fullness near the supratonsillar fossa surgical drainage is indicated. This is best performed under local anesthesia with topical applications or cocaineization of the sphenopalatine ganglion. A sharp knife is pressed through the top of the anterior pillar or just underneath its edge into the abscess cavity until a trickle of pus is seen to follow its withdrawal. A sharp pointed hemostat is then introduced into this same tract to the center of the abscess and is then forcibly opened enlarging the drainage tract and providing free exit to the pus. This latter procedure is momentarily very painful but the succeeding relief is so rapid and complete as to more than justify it. No special treatment is needed beyond some cleansing gargle or irrigation.

#### LATERAL PHARYNGEAL ABSCESS

Somewhat similar to and often mistaken for true peritonsillar abscess is an infection of the throat best designated as a paratonsillar or lateral pharyngeal abscess. In these cases there is found a localized collection of pus external to the superior constrictor muscles of the pharynx either lateral to the tonsil or just behind it. If the pus forms posterior to the tonsil there will appear a bulge in the pharyngeal wall, which gradually shows definite fluctuation. As soon as this is present incision and drainage is indicated best carried out even in children without anesthesia. Where the pus forms lateral to the tonsil the removal of the latter may be

the ideal procedure in the approach to incision and drainage the abscess being found to lie directly outside the tonsillar bed. In some instances when the infection is more deep seated and occupies the region known as the pharyngomaxillary fossa in close approximation to the great vessels in the neck particularly if accompanied by signs and symptoms of general systemic and blood stream infection the approach should be from the outside. A generous incision should be made with dislocation of the submaxillary gland and the tract should be followed above the posterior belly of the digastric muscle toward the styloid process (as advocated by Mohr). This approach will reach almost any collection of pus in the pharyngomaxillary fossa.

### RETROPHARYNGEAL ABSCESS

A throat infection of great importance is that known as retropharyngeal abscess. Much more common in infants than in older children and adults this condition arises as a collection of pus behind the posterior pharyngeal wall anterior to the prevertebral fascia. It is rarely directly in the midline but not so far lateral as the true lateral pharyngeal abscess. It is most often due to an infection of a prevertebral lymph node secondary to some minute pharyngeal infection. Rarely it is of tuberculous origin originating as a cold abscess secondary to involvement of the cervical vertebrae. The retropharyngeal abscess varies greatly in the depth of its location. It may be high clearly visible above the base of the tongue or so low down as to be scarcely palpable to the examining finger and hence to constitute at most a retropharyngeal abscess. When it is located high up the symptoms are suggestive of some low grade respiratory obstruction such as is encountered with hypertrophied adenoids. There is a snorting or snuffing type of breathing with some nasal discharge. In addition there is usually a story of some difficulty in swallowing i.e. refusal of food regurgitation or marked dysphagia. More serious than any of these symptoms however is that of increasing dyspnea due in the lower location to pressure against the larynx and upper portion of the trachea. The possibility that such respiratory obstruction in an infant may be

due to retropharyngeal abscess must never be forgotten if an occasional tragedy is to be avoided. For some reason examination of these babies is fraught with considerable risk and the opening of a mouth gag or insertion of a laryngeal speculum has been followed by sudden death possibly from some effect of pressure on the vagus. Roentgen examination will almost always confirm the diagnosis by evidence of a greatly widened space between the trachea or larynx and the cervical spine. Forewarned is forearmed no matter how suggestive the history of intrinsic respiratory obstruction may be the possibility of retropharyngeal abscess must always be kept in mind.

The preferable method of treatment is carried out with the child lying on the table with extended head and elevated shoulders. By reflected light the operator seated on a stool and facing the child's feet exposes the retropharyngeal wall by elevating the tongue and hence the larynx with an angular tongue depressor much as one would hold a laryngoscope. This provides a constant free airway to the glottis and brings into view the pharyngeal swelling even if it is below the level of the larynx which is always at a higher level and hence safe from aspiration of pus. Under direct illumination a knife is then passed into the abscess its contents slowly aspirated and the wound edges spread apart to afford good drainage. Usually no after treatment is necessary and secondary incision is rarely required.

I FLET COMMANDEER LYMAN RICHARDS

## NEOPLASMS OF THE NOSE, PHARYNX AND NASAL SINUSES

### BENIGN NEOPLASMS

**Nasal Polyps**—Nasal mucous polypoidematous fibroma or myxoid fibroma usually multiple and bilateral is the most common benign nasal tumor and has a great tendency to recur. It is a smooth oval usually pedunculated translucent mass growing from the mucosa over the middle turbinated bone the ostia or the sinuses.

**Etiology**—Formerly chronic infection was accepted generally as the cause of this growth<sup>1</sup> but recently both clinical and laboratory studies have shown that allergic

sensitivity is the underlying constitutional cause. Kern and Schenck have stated and from personal experience the writer concurs with them that true nasal mucous polyps are rare in patients with non allergic disease even in the presence of extensive sinus infection.

**Pathology**—An edematous mucous membrane is the chief pathologic finding ciliated cells are few or absent. Plasma cells mononuclear cells and lymphocytes may be found but eosinophils usually are abundant and may be the only cells encountered.

**Symptomatology**—Nasal obstruction sneezing watery or purulent discharge depending on the amount of secondary infection cough and bronchial asthma are the predominant symptoms.

**Diagnosis**—The family and personal histories of allergy are of the utmost diagnostic importance. The appearance and situation of the growths the presence of eosinophils in the blood and nasal secretions protein sensitivity tests and x-ray examination of the sinuses all aid in establishing the diagnosis.

**Treatment**—Treatment consists in avoidance of or desensitization for offending allergens surgical removal of the polyp by snare and forceps and treatment of the accompanying sinusitis.

**Other Benign Nasal Tumors**—Other benign tumors of the nose include the (1) fibrous polyp which is characterized by hypertrophy of the mucous membrane and is often associated with infection of long standing (2) fibroma and (3) enchondroma which are treated by surgical removal (4) angioma usually situated on the septum and treated by cautery or destruction by radium (5) epithelial papilloma which is a precancerous lesion and demands thorough surgical removal cauterization of the base or electrodesiccation (6) psammoma or brain sand tumor which probably always originates from the dura and may protrude into the ethmoid area and demands surgical removal (7) Schwannoma or neurofibromatosis which is due to a proliferation of the cells in the sheath of Schwann and (8) chordoma which arises from the cellular remains of the notochord is of epithelial origin grows from the sphenoid-occipital region and when removed surgically tends to

recur is slowly malignant and occasionally metastasizes.

**Osteoma**—Osteomas are slow growing benign bony tumors originating from the interior of the frontal sinus the orbit the ethmoid the antrum or the sphenoid. Such growths may involve the frontal and ethmoid sinuses and the orbit. They are not common less than 300 cases having been reported. By far the greatest number occur in patients who are in the second and third decades of life.

**Etiology**—A definite history of injury can sometimes be obtained but it is doubtful whether either trauma or infection is an etiologic factor.



Fig 410—Osteoma of the ethmoid in a boy aged seventeen with encroachment on the right orbit producing exophthalmos diplopia and loss of vision. Operation was performed with relief of symptoms.

**Pathology**—These tumors may be irregular sessile or pedunculated and may be composed of (1) hard eburnated bone (2) spongy bone or (3) a mixture of these two types. Grossly they cannot be distinguished from normal bone.

**Symptomatology**—Small osteomas within the sinuses may cause no symptoms and are discovered only when an x-ray examination is made for other reasons. The first sign may be an acute sinusitis. Later the symptoms are those resulting from the growth of the tumor—headache pressure on surrounding nerves or paralysis. If the tumor is situated in the nasal cavity it produces obstruction and external deformity. If it grows into the

orbit it may cause diplopia proptosis or even loss of vision as a result of pressure. Invasion into the cranial cavity usually produces very severe headache. Osteoma of the frontal sinus may produce vertigo reflexly.

**Diagnosis**—Headache and deep pain lead the patient to seek relief and roentgen examination reveals the size origin and structure of the growth. Cysts may be differentiated from osteoma by puncture. Mucocoele may be differentiated by the thinning of the bone and by the roentgenographic appearance. Syphilitic growths involving the soft tissues or the bone may be mistaken for osteoma but roentgenographic and serologic examinations usually make differentiation possible.

**Prognosis**—The mortality rate in cases of osteoma without operation has been estimated at 48 per cent.<sup>8</sup> Complications can arise from encroachment on the cranial cavity or surrounding structures. An osteoma within an acutely inflamed frontal sinus may take on serious aspects. If the tumor is situated around vital parts its removal may be impossible. An osteoma of the sphenoid is generally inoperable because of the danger of injuring the brain the internal carotid artery or the cavernous sinus. In uncomplicated cases when the osteoma can be removed completely the results are satisfactory and the growth does not recur.

**Treatment**—An osteoma should be removed as soon as it is discovered even though it is not producing symptoms for the possibility of its rapid growth with invasion of the meninges and other vital structures is always imminent.

**Nasopharyngeal Fibroma**—Nasopharyngeal fibroma is a rather rare tumor of young adult life which occurs chiefly in males. It may grow from any part of the nasopharynx which contains fibrous tissue. It is rounded and smooth occasionally lobulated is covered by mucous membrane is composed of connective tissue and seldom shows calcification cartilage or bone. The tumor has an abundant blood supply the vessels generally are of large size and have thin walls. The usual site of origin is from the periosteum and the anterior portion of the base of the occipital or sphenoid bone.

**Pathology**—The growth contains spindle cells round cells and giant cells and is some

times difficult to differentiate pathologically from sarcoma.

**Symptomatology**—Nasal obstruction muffled voice and pressure against the eustachian tubes are the most prominent symptoms. As in sarcoma pain does not appear until the tumor attains sufficient size to cause pressure on the surrounding nerve trunks. There may be repeated attacks of bleeding from the tumor and if the growth is large pressure may cause spreading of the surrounding bone.

**Diagnosis**—A diagnosis can be made from posterior rhinoscopy and from the hard consistency of the tumor on palpation.

**Treatment**—The mortality rate from operation alone has been high because of profuse hemorrhage. Destruction of the tumor by electrocoagulation or radium yields far more satisfactory results.

### MALIGNANT NEOPLASMS

Malignant neoplasms of the nasal passages do not produce definite pathognomonic signs and symptoms in their early curable stages. The first signs are those of inflammation and hence malignant tumors may be overlooked unless complete investigations are made on every patient whose symptoms are out of proportion to the apparent disease and who has persistent unilateral epistaxis. All tissues removed at operations on the nose and sinuses should be examined by a competent pathologist who is thoroughly familiar with the histology of nasal tissues and if there is the slightest doubt a biopsy should then be performed. The specimen should always include more than the overlying granulation and inflammatory process and should contain sufficient tissue to enable the pathologist to render a definite opinion.

Often what has been mistaken for a recurring benign polyp has been removed from the nose several times before a tumor of malignant type was recognized. Very frequently what appears to be chronic inflammatory tissue or bleeding granulations is removed or craterized without histologic examination and the malignant process is recognized only when the growth has attained considerable size or has metastasized widely.

As in cancer elsewhere in the body com-

plete surgical removal is the ideal treatment but often this is not possible. If an operation is undertaken it should be comprehensive and complete so that all that is necessary can be accomplished at one time. Since the surgical dictum for cancer else where that is removal of the growth with a margin of safety and care not to handle the cancerous tissue cannot apply to this region electrocoagulation cautery and irradiation must be employed in practically all cases. Many perhaps most of the malignant growths in the nasal passages and pharynx are radiosensitive hence irradiation is advised even in surgical cases and is always employed in inoperable cases.



Fig. 413.—Malignant tumor of the left maxillary sinus in a woman aged forty. Note the destruction of the nasal wall and the protrusion of the growth into the nose and also the destruction of the outer wall of the sinus.

**Malignant Tumors of the Sinuses.**—A primary malignant tumor may occur in the frontal sinus but the antrum and ethmoid sinus are far more frequent sites of this disease. Carcinoma of the ethmoid or antrum seldom invades the frontal sinus but frequently spreads to the sphenoid and the orbit but the hard palate, septum and sphenomaxillary fossa.

**Pathology.**—Of thirty two malignant tumors of the sinuses observed at the Cleveland Clinic four were sarcoma and twenty seven carcinoma. This preponderance of carcinomatous lesions agrees with the experience of other observers.<sup>9-10</sup> The epidermoid carcinoma is the most malignant the basal cell the least so. The transitional cell medullary type spreads to the glands quickly

while the keratinized tumor does not extend into the surrounding glands. Metastases to the lymph nodes usually are late.

**Symptomatology.**—Ethmoid cancer produces early unilateral epistaxis which is followed promptly by nasal obstruction and later by pain. There may be a sensation of fullness in the antrum or of something in the cheek. Pain is referred to the alveolus or the hard palate on the affected side and increases as the tumor grows.

**Diagnosis.**—When more than one sinus is involved it is difficult to determine the site of the primary lesion. Nasal hemorrhage and obstruction point to the ethmoid sphenoid region pain around the teeth points to the antrum. Pain in the alveolus often is attributed to dental infection especially since diseased roots and gums frequently accompany cancer in the vicinity of the mouth and sinuses.

Swelling of the cheek bulging of the nasomaxillary wall or of the hard palate exophthalmos and a tumor mass in the nose are paramount signs of a malignant growth in the sinuses. Transillumination yields no decisive evidence but an x ray examination of the sinuses reveals whether the tumor has destroyed or broken through the bones. Large cysts mucocoele fibroma fibromyxoma and osteoma must be considered in the differentiation but exploration and biopsy establish the diagnosis.

**Prognosis.**—In our series of cases of carcinoma of the sinuses there has been one twelve year cure one eight year cure one six year cure and one two year cure. One of the patients with sarcoma survived for eight years and another for three years. Invasion of the surrounding soft tissues by a malignant growth of the sinuses makes the prognosis unfavorable.

**Treatment.**—Complete surgical removal or destruction and removal by surgical diathermy followed by radium irradiation leaving the cavity open for inspection for a year or more is the treatment of choice. Operation is possible in any case in which there are no metastases to the brain or the neck. Extreme care should be exercised in the preoperative preparation so that the patient's general condition is improved as much as possible. Tracheostomy may be necessary to facilitate the operation.

The site of the primary incision depends on whether the antrum alone is involved or whether there is invasion of the ethmoid sphenoid region or the orbit. Although the frontal sinus is not often the site of cancer it may be infected because of blocking of the nasofrontal duct and should be cleared out. Hence the incision may be made to include the frontal sinus as well as the antrum and ethmoid. Care should be used to keep the incision away from the eye.

The tumor is removed piecemeal. If the orbit is invaded it may be necessary to sacrifice the eye. The wound is left entirely open. Immediately following the operation radium should be inserted with the hope of destroying any hidden cancer cells. Treatment after operation is prolonged and is limited to removing slough and to the cleansing of the whole area. With the open cavity, radium can always be applied later to any area in which cancer is suspected. The defect in the cheek may be closed by a plastic operation and if the orbit has been sacrificed a prosthesis incorporating an artificial eye and held in place by glasses can be arranged.

Radiation is applied in inoperable cases. The pain may be severe and an alcohol injection or section of the sensory root of the fifth nerve may be necessary to afford the patient some relief.

**Malignant Tumors of the Nasopharynx**—*Pathology*—Most of the growths which arise in the nasopharynx are carcinomatous but sarcomas also occur. In a group of thirty-two cases in the Cleveland Clinic twenty-three were carcinomas and nine were sarcomas.

*Symptomatology*—A malignant growth in the nasopharynx may be so small that it causes no local symptoms and the first sign may be extensive metastasis in the cervical lymph nodes. There may be a mucous catarrh of the eustachian tube, unilateral impairment of hearing and as the growth progresses obstructive symptoms and dysphagia. The pain is neuralgic in character.

*Prognosis*—These growths usually are of a high grade of malignancy and metastasize early and widely. In our series of cases only one patient with carcinoma survived for five years, one with sarcoma survived for eleven years.

*Treatment*—Surgical removal of the tumors is usually impossible because of their situation; hence both external and interstitial irradiation are employed.

**Malignant Tumors of the Tonsil and Pharynx**—Malignant tumors of the tonsil and pharynx are rather rare. They may arise from the soft palate, the pillars, the tonsil or the mucous membrane. Their early clinical diagnosis while the disease is confined to the primary area is difficult. It is impossible to distinguish between carcinoma and sarcoma unless a biopsy is made.

*Pathology*—The gross classification of carcinoma of the tonsil includes papillomatous, non-papillomatous or flat types; the latter may be ulcerative or non-ulcerative. The principal pathologic types of carcinoma of the tonsil are the squamous cell, which is the more common, and the transitional cell. Sarcomas of the tonsil may be lymphosarcomatous or fibroblastic.

*Symptomatology*—The early symptoms of malignant tumors of the tonsil or pharynx are those of benign hypertrophy, inflammation or peritonsillar abscess. There is a sense of fullness and the pain often simulates neuralgia. The consistency of the growth is hard.

If the hypertrophied tonsil is removed at this stage by the surgeon who does not suspect the presence of cancer, there is a rapid filling in of the tonsillar fossa with return of the growth, which is likely to extend rapidly beyond the tonsillar capsule and invade the regional lymph nodes. Late symptoms are constant clearing of the throat, deep pain, dysphagia, salivation, offensive odor and fixation of the jaw.

*Prognosis*—These tumors extend rapidly and the transitional cell tumors spread quickly to the regional lymph nodes. Broders places about 60 per cent of these tumors in his classification as of grade IV malignancy.

*Treatment* is surgical and radiological. Operation yields a high rate of mortality and poor prospects of permanent cure. The majority of sarcomas are extremely radiosensitive and the application of radium and deep x-ray is the treatment of choice. The Coutard method or some modification of it is usually employed and the important points are continuity of treatment and ade-

quate dosage.<sup>13</sup> Lymphosarcoma usually disappears at the original site rather quickly, only to recur elsewhere.

If operation is performed, the external carotid artery is tied; an incision is made from the symphysis of the jaw to the sternal notch, the hyoid bone is split; the attached muscles are turned back and the digastric muscle and the submaxillary gland are turned upward, and the growth is removed with the electrocautery knife.<sup>14</sup>

**Malignant Mixed Tumors.—Pathology.**—Malignant mixed tumors are derivants of the ducts and acini of the mucous glands in the oral cavity. The writer has seen one such tumor arising from the eustachian tube. These growths usually are not encapsulated and must be classified as of a low grade of malignancy. They tend to recur locally, and if they metastasize, they do so late.

**Diagnosis**—These tumors can usually be recognized by their firm, smooth surface—a single circumscribed nodule lying under the mucous membrane.

**Prognosis**—In these cases the prognosis usually is good.

**Treatment**—If the growth is discovered early and has not invaded important surrounding structures, treatment is surgical, and it usually is possible to remove the tumor completely. Whatever method is used whether removal by operation or destruction, with electrocoagulation or deep roentgen therapy, it is important that the growth be removed completely the first time. Deep therapy reduces the size of the tumor and should be used only if complete surgical removal is impossible.

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## THE SALIVARY GLANDS AND DUCTS

**Salivary Fistula.**—Operative incisions and accidental wounds about the face may involve the parotid gland or duct and result in a discharge of saliva through the opening in the skin of the cheek. If the wound is infected, the presence of saliva may at first be disguised by the flow of pus, but as the infection clears up, the diagnosis of salivary fistula will be indicated by the persistent discharge of clear fluid. In the early care of wounds over the region of the parotid duct, the formation of a fistula may be prevented by suturing the severed ends together if they can be found.

A salivary fistula following a wound over the gland itself, in which the duct remains patent, is usually not permanent and will heal spontaneously after a few days or weeks, especially if the salivary flow is reduced by keeping the patient on a liquid

or soft diet and avoiding active mastication. In stubborn cases movement of the lower jaw may be absolutely restricted by wiring the upper and lower teeth together.

Salivary fistula resulting from a loss of continuity of the main parotid duct presents a more difficult problem. Here the mucous lining of the end of the duct proximal to the wound becomes continuous with the skin and little or no saliva enters the mouth through its natural channel. The site of the fistula is significant from the standpoint of treatment according to whether the opening is in front of or behind the anterior border of the masseter muscle. Many methods of operation have been proposed. If the fistula is well in front of the masseter muscle it may be possible to dissect the proximal end of the duct free and implant it into the buccal mucosa so that the saliva will flow into the mouth, the skin margins of the opening being then freshened and sutured. Another plan is that of Kaufman, which consists in passing a small drainage tube through the cheek at the site of the fistula so that its end protrudes into the mouth. The tube is gradually withdrawn from the inside, establishing a permanent opening there, while the external fistula is allowed to heal.

Where the fistula is over the masseter muscle a new anterior part of the duct may be constructed by making a tube from a flap of buccal mucosa turned back and joined to the remains of the original duct.

#### PYOGENIC INFLAMMATION OF THE PAROTID GLAND

Blair and Padgett<sup>1</sup> divide the cases into two broad groups: (1) those in which acute inflammation of the gland is the most prominent symptom and (2) those presenting recurrent symptoms of obstruction of the duct with added inflammation of the gland. The obstruction may be caused by swelling of the mucosa, a plug of mucus or a calculus.

**Acute Pyogenic Parotitis.**—Acute pyogenic parotitis usually occurs as a complication of a postoperative condition of an infected wound of an acute infectious disease or as a part of a terminal condition. Most commonly the infection is believed to ascend from the mouth along the lining mucosa of Stensen's duct, though it may at times be blood borne. The organism is generally a

staphylococcus but is occasionally a streptococcus. Usually there is a sudden onset with pain and tender swelling in the region of the gland and general symptoms of a severe infection such as chills and high fever. Examination of the orifice of the duct in the mouth usually shows it to be bright red and swollen with cloudy or purulent saliva flowing from it. The swelling is usually unilateral but both glands may be involved. As pus distends the gland the overlying skin becomes red and edematous and fluctuation may be detected. In Blair and Padgett's series of thirty-five cases the death rate was 42.8 per cent.

**Treatment.**—Beginning mild cases are treated by application of heat or cold. When it becomes evident that suppuration is present drainage by incision is imperative unless the condition is a terminal one.\* By making a vertical incision at the junction of the cheek with the ear, noticeable scarring is avoided. The incision passes down to the capsule of the gland and the skin anterior to it is retracted forward. The capsule is then split horizontally in several places to avoid cutting branches of the facial nerve and openings are made deep in the substance of the gland. The wound is picked wide open with gauze. After healing very little scar remains and usually there are no signs of paralysis of the seventh nerve.

**Obstructive Parotitis.**—Obstructive parotitis is preceded by recurrent swelling usually accompanied by some inflammatory disturbance in the duct. The pain and swelling may be especially pronounced when food is taken. Examination will often reveal a discharge of pus from the duct into the mouth and a stone may be located with a probe or by x-ray examination. Complete obstruction may be followed by abscess formation, the condition then resembling the form already described. In cases belonging to the second group recovery usually follows removal of the obstruction of the duct or drainage of the abscess.

**Treatment.**—For cases of obstruction due to swelling of the lining without stone, Hobbs, Snerson and Faust<sup>2</sup> recommend dilation with graded whalebone filiforms until the duct will allow the entrance of a 22 or 20 gauge needle. Then 2 or 3 cc of saline solution or 2 per cent mercuriochrome is



slowly instilled. The treatment may be repeated daily or at intervals of several days according to the symptoms. If a calculus is present in the duct it should be removed if possible through an incision in the mucosa of the cheek. In chronic inflammation with out stone Blair and Piddgett reported good results by slitting the constricted meatus and suturing its epithelial lining to the mucosa of the cheek. When definite acute abscess forms in the gland drainage by external incision is indicated.

#### PYOGENIC INFLAMMATION OF THE SUBMAXILLARY GLAND AND DUCT

A similar condition to that observed in the parotid gland may occur—and more frequently—in connection with the submaxillary gland and its duct. The usual cause is obstruction of Wharton's duct by a salivary calculus although cases in which the same symptoms were present but in which it was impossible to locate any stone have been occasionally observed. In a series of seventy-three cases of salivary calculus reported by the writer<sup>3</sup> sixty-six were connected with the submaxillary duct and seven with the parotid, a proportion of almost ten to one.

**Symptoms and Diagnosis.**—In typical cases the diagnosis should offer no difficulty. There is an acute circumscribed swelling beneath the lower border of the mandible in front of the angle, not connected with the bone and not adherent to the skin. Pain may be severe especially on swallowing. This painful enlargement is particularly noticeable when food is taken. The patient is able to open the mouth. A tender edematous swelling will generally be found in the floor of the mouth along the course of the duct. The outlet of the duct at the side of the frenum of the tongue is usually reddened and pus may be expressed from it. A tender hard nodule—the calculus—may be felt somewhere along the course of the duct by combined intraoral and extraoral palpation. In the milder or subacute recurrent cases the diagnosis may present more difficulty. Here the only indication may be more or less recurrent attacks of circumscribed tender swelling in the submaxillary region. The possibility of calculus should always be thought of under these circumstances and careful inspection will frequently show red-

ness or swelling about the orifice of the suspected duct or pressure may force out a little pus. X-ray examination is valuable in making the diagnosis of submaxillary stone if made with the proper positions. When a calculus is suspected in the anterior two thirds of Wharton's duct a 2½ by 3¼ inch film is placed in the occlusal plane between the upper and lower teeth as far back as possible and the rays are directed from beneath the chin. This bite film will give a clear shadow of any opaque substance in the floor of the mouth. If the stone is far back near the gland a lateral extraoral film may be necessary to show it.

**Differential Diagnosis.**—Obstructive enlargement of the submaxillary salivary gland is commonly mistaken for a lymphadenitis or a cellulitis due to infection from teeth or tonsils. Careful note of history and symptoms and examination as outlined above with *absence of trismus* will usually exclude a cellulitis of dental origin.

The presence of a subacute swelling in the submaxillary region associated with soreness in the floor of the mouth especially in a person of middle age or beyond may lead one to entertain a suspicion of malignant growth. In a carcinomatous metastasis to submaxillary and cervical lymph nodes the mass in the neck is usually fixed and markedly indurated frequently bound both to the skin and to the bone. When the submaxillary gland is enlarged because of a stone in the duct it is usually more deep seated, is not fixed to skin or bone and has an elastic feeling. The x-ray examination usually clears up the question.

**Treatment.**—The treatment of obstruction of Wharton's duct by a calculus consists of removal of the calculus through an incision in the floor of the mouth if possible. When the calculus is far back near the gland it is generally necessary to make a skin incision and remove the submaxillary gland as well as the stone.

#### RANULA

A ranula is a soft painless semitransparent swelling beneath the mucous membrane of the floor of the mouth containing clear rosy fluid. The exact cause is unknown but it may be due to inflammatory closure of one of the ducts of the sublingual

gland or of one of the smaller mucous glands in this region. It is never associated with a calculus nor with a swelling in the submaxillary region as would be the case if the submaxillary duct were involved. Furthermore, in ranula the submaxillary duct can usually be identified and isolated completely from the cystic swelling.

Ranula usually starts on one side of the median line but as the fluid accumulates the swelling increases so that it may appear to be bilateral. The overlying tissue becomes very thin and finally ruptures discharging a semifluid resembling white of egg. The swelling then subsides and the process repeats itself.

Several methods of treatment of ranula have been suggested including removal of the overlying tissue to create a permanent wide opening but the only way of insuring cure is by complete dissection of the sac.

#### TUMORS OF THE SALIVARY GLANDS

**Mixed Tumor**—The tumor which most commonly affects the salivary glands is the so-called mixed tumor which occurs usually in the parotid region but is also occasionally found connected with the submaxillary gland. Mixed tumors may also be found in the palate lip and cheek. The mixed tumor appears as a well defined firm swelling sometimes smooth sometimes nodular in the region of the salivary gland with the skin freely movable over it. It increases slowly in size over a period of years and is painless. If untreated it may reach the size of a grapefruit. These tumors while appearing in the region of the salivary gland or even embedded in it are not really part of the gland but are distinctly encapsulated. Histologically the characteristic cells are difficult to classify but are probably of epithelial origin. In parts there is a definite arrangement of these epithelial cells in the form of acini in others there are large amounts of colloid material. Cartilage and bone formation occurs occasionally. On section into the growth the tissue is found to have a peculiar gelatinous consistency.

**Prognosis**—These growths are not to be regarded as malignant though local recurrence is common if removal has not been complete. Cure usually follows removal.

**Treatment**—When small and well encapsulated the tumor should be enucleated.

Removal of large growths in the parotid region may be attended with danger of injury to the facial nerve. Radium and x-ray treatment are not very successful.

**Carcinoma**—Carcinoma may occur in the parotid gland and produces a hard fixed swelling accompanied by pain. If it is untreated ulceration of the overlying skin may occur. Paralysis of the seventh nerve is a frequent accompaniment. Treatment consists in early removal of the entire gland followed by irradiation.

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#### THE JAWS

##### INFECTIONS OF THE MAXILLARY BONES

Nearly all cases of infection of the maxillary bones are directly or indirectly of dental origin. However, general diseases such as syphilis and tuberculosis may be etiologic factors even though pyogenic infection from the mouth plays an important role. Poisons such as mercury, arsenic, phosphorus and radium salts cause periostitis and osteomyelitis of the jaw bones either by their direct action or by lowering the resistance of the tissues so that pyogenic bacteria gain entrance through diseased teeth and gums.

**Etiology**—The commonest causes of periostitis, osteomyelitis and necrosis of the jaw bones are local infections following dental alveolar abscess, stomatitis or fracture.

Sometimes the pus of a dental alveolar abscess instead of making its exit through a perforation in the bone near its point of origin spreads through the cancellated tissue of the mandible causing osteomyelitis. In other cases the periosteum is stripped off the bone to such an extent as to impair the vitality of a certain portion. The hypodermic injection of a local anesthetic into

acutely inflamed tissues for the extraction of a tooth may carry infection ahead of it thus leading to periostitis and osteomyelitis. Injudicious extraction of a tooth in the very acute stage of pericementitis especially when considerable trauma is entailed frequently is followed by inflammatory bone complications. Periostitis and osteomyelitis generally result in bone necrosis. Cases have been recorded in which the sequestrum comprised the entire mandible. Regeneration of bone after necrosis is much more frequent in the mandible than in the maxilla.

**Symptoms.**—Inflammatory disease of the jaw bones may be divided clinically into two stages. (1) the acute fulminating stage and (2) the more chronic stage of sequestrum formation. In its earlier stages osteomyelitis is difficult to distinguish from acute dental abscess as severe pain, swelling and fever usually accompany both. In every dental abscess there is necessarily a localized bone infection. If the symptoms persist or involve a more extensive area of the jaw after incision and drainage of the primary abscess the development of osteomyelitis should be suspected. In an advancing case the swelling extends along the bone, the teeth become successively loosened and pus is seen discharging into the mouth around the necks of the teeth. The pus also burrows from the outer surface of the bone toward the skin and if the swelling is not incised will perforate the skin surface forming sinuses. A probe passed through these openings will feel denuded bone. Exposed bone may also be visible through the mouth. After about six or eight weeks sequestra will loosen and in some cases will be thrown off spontaneously. Pathologic fracture may occur. Quite frequently in the mandible however an involucrum of new bone is formed which preserves the continuity of the jaw. X-ray examination affords little information in the acute stages of osteomyelitis before marked disintegration of the bone has occurred. In the stages of necrosis the x-ray picture is valuable in outlining sequestra, new bone formation, pathologic fracture, involvement of teeth, etc.

**Treatment.**—Adequate drainage should be provided in all infections of the mouth. Any cause that may be manifest such as an abscessed tooth should be removed unless

the case is seen in the acute fulminating stage when the trauma of the tooth extraction might aggravate the infection and open up new channels. When there are indications that pus is present it should be evacuated. This can sometimes be accomplished by an incision within the mouth especially when the upper jaw is involved but in the lower jaw external incision is usually necessary. The incision should be planned so as to give dependent drainage; it should be adequate but not larger than necessary, it should follow the natural lines of the skin and should be so placed that the resulting scar will be concealed as far as possible; it should avoid severing important structures. For example, the incision for drainage of a submaxillary abscess should be made well beneath and parallel to the lower border of the mandible in front of or behind the position of the facial artery according to the place of greatest pointing. Incisions above the lower border of the mandible should be avoided if possible. When it is evident that some necrosis will occur waiting for the separation of sequestra by natural processes brings about far better results than radical removal of diseased bone or injudicious curetting. By providing proper drainage and irrigation and then removing sequestra as they form it is possible to have the lost bone almost completely replaced and to avoid any great deformity and interference with function. On the other hand if the diseased bone is resected before sequestration is complete there is generally great interference with regeneration resulting in unsightly distortion of the face, malocclusion of the teeth or non-union of the remaining portions of the bone.

#### NEOPLASMS OF THE JAWS

A convenient clinical grouping of the more common tumors and conditions resembling tumors about the jaws is the following: (1) epulis, (2) osteoma, (3) benign giant cell tumor, (4) sarcoma, (5) tumors cysts and anomalies of dental origin, (6) metastatic and secondary growths and (7) miscellaneous conditions resembling tumors.

**Epulis.**—Though this term has been objected to on the ground that it simply means any growth on the gum when applied to a definite clinical entity it serves a useful purpose. The characteristics of epulis are: a cir-

circumscribed growth from the alveolar ridge and gingival margin, around the necks of the teeth, having generally a rather narrow attachment and spreading thence over the gum surface, often hiding the crowns of the teeth and displacing them (Fig 444). This definition would exclude growths away from the gum margin, surface growths, such as papillomas, etc. In the early stages epulis may be essentially a chronic inflammatory growth, due to irritation of food or tartar beneath the gum margin, ill-fitting crowns and fillings, or carious cavities in teeth. Some pathologists claim that histologically, at least, an epulis is not a tumor but should be classed as an infectious granuloma. Clinically and grossly, however, it has many of the

consists of an interlacing network of fibrous tissue with round cell infiltration.

The *fibroangioma* is usually softer, grows more rapidly, is bright red and bleeds more easily than the plain fibroma. In the fibrous connective tissue stroma are seen numerous dilated capillary blood vessels.

The *giant cell epulis* is soft, is characteristically dark red or purplish and may increase rather rapidly in size. Microscopically, beneath the covering mucous membrane, there is seen a stroma of fibrocellular tissue, and scattered throughout are multinucleated giant cells. Small masses of bone and cartilage may be found. These growths were formerly called giant cell sarcomas and, regarded as malignant, gave rise to radical and



Fig 444—*a*, Epulis, *b*, roentgenogram showing dental root cyst connected with the maxillary second incisor

characteristics of a tumor and for this reason it is included in the present classification.

Clinically and pathologically three forms of epulis are recognized. (1) fibroma, (2) fibroangioma and (3) benign giant cell tumor. All three types arise from the dental periosteum about the neck of a tooth.

*Fibroma* is the most prevalent form. Soft at first, it later appears as a hard nodular mass on the gum surface, usually pushing out from a narrow pedicle between two teeth, sometimes displacing the teeth. The covering mucous membrane may be bright red, although it generally resembles that of the normal gum. Fibromas are nearly always slow in growth. Histologically, there is an outer layer of normal stratified squamous epithelium, while the mass of the growth

mutilating operations and unnecessary sacrifice of tissue. It is now known that these growths are not malignant and that they require only local removal. Some pathologists regard the giant cell epulis as a manifestation of osteitis fibrosa.

*Treatment of Epulis*—The great majority of epulides spring from the alveolodental periosteum about the necks of the teeth, and in order to avoid recurrence it is necessary to remove the growth down to the responsible dental periosteum. This usually means that the tooth nearest the growth or perhaps two teeth must be removed. The growth often comes away in extraction attached to the neck of a tooth. Destruction of the growth by radium is not advised, because an entirely unnecessary slow healing

with painful ulceration results probably with exposure and necrosis of bone

**Osteoma.**—Osteoma is found more commonly in connection with the maxilla than with the mandible. It forms a dense painless circumscribed enlargement slow in growth pushing out from the surface of the bone. The dense character clinically and radiologically distinguishes it from a cyst or sarcoma. The diffuse character of many of these growths makes complete removal difficult or impossible but often good results are obtained by chiseling away enough of the excess bone to form a normal contour and repeating the process if necessary.

**Benign Giant Cell Tumor.**—A benign giant cell tumor may arise from the interior of the bone causing expansion of the cortical plate. If the cortical plate or the alveolar margin becomes perforated by the tumor the mass will have the typical purplish color seen in the epulis type. Otherwise absolute differentiation from true sarcoma may not be possible before operation. On incision the tissue is dark red as contrasted with the pale gray of the more malignant sarcoma. It is now established that the benign giant cell tumor of bone is a definite stage of osteitis fibrosa cystica. It usually responds well to enucleation and curettage of the mass without encroaching extensively into the surrounding healthy bone.

**Sarcomas.**—Sarcomas of various types involve the maxilla just as they do other bones. The endosteal form appears to be the most common causing a painless expansion of the bone at first slow but later progressing more rapidly. In the upper jaw, the maxillary sinus may be invaded with later involvement of the nasal fossa and other sinuses. The x-ray picture is important in distinguishing sarcoma of the jaw from cysts and tumors of dental origin. Benign giant cell tumors and other growths. Sarcoma shows in the x-ray film a peculiar honey-combed appearance with irregular outline. Sarcoma may affect persons at any age. Metastasis occurs through the blood stream and the lungs usually show the first signs of secondary involvement. In many of the slow growing sarcomas of the jaws metastases do not occur until late and the prognosis is correspondingly favorable.

Combined treatment by radical surgery

roentgen ray and radium is regarded as giving the best hope for cure.

**Tumors, Cysts and Anomalies of Dental Origin.**—A full discussion of these would require more space than can be afforded here. This group comprises what are often classed together under the term odontoma though the writer prefers not to use this term because some of the conditions are not tumors at all but are inert calcified abnormal masses of tooth structure.

The first heading to be considered is that of *dentocystic tumors* of which there are three forms: (a) adamantinoma or ameloblastoma, (b) dentigerous or follicular cyst and (c) dental root cyst or radicular cyst.

**a Adamantinoma or Ameloblastoma.**—The adamantinoma is the least common of the three forms of dentocystic tumor. It is believed to be due to aberrant growth of the ameloblasts or enamel forming cells of the tooth germ although there is never any calcified enamel in the tumor. The portion of the jaw involved usually the molar region of the mandible but not necessarily so is distended containing a lobular mass within a bone cavity or there may be several cavities divided by fibrous or bony septums. In the earlier stages the growth may consist largely of solid tissue but numerous cysts are formed later which may finally coalesce into one or two large cysts filled with a viscid yellowish or brownish fluid. Histologically there are nests of columnar and cuboidal epithelium corresponding to ameloblasts surrounding less dense areas with compressed cell bodies resembling the stellate reticulum of the enamel organ. These epithelial areas are surrounded by a supporting connective tissue containing blood vessels. Accumulation of fluid in the cysts may compress the lining epithelium until it becomes squamous. The surrounding bone may be gradually absorbed the tumor cells then breaking through and invading the surrounding soft tissues. Metastases however are practically unknown only two undoubted cases having been recorded (by Simmons<sup>1</sup>). In general it may be said that the tumor is to be regarded as benign. It may be found at any age. McFarland and Patterson<sup>2</sup> have reviewed 106 cases reported in the literature.

**Symptoms and Diagnosis.**—The patient

presents a painless swelling usually in the molar region of the mandible which has been slowly increasing in size. The jaw is found to be expanded the outer plate being more affected than the inner. When the tumor has broken through the bone it may present a lobulated surface and an elastic feeling on pressure. If an opening into a cystic cavity exists a fluid discharge is seen that is usually viscid and brownish. Infection may occur and obscure the nature of the tumor by showing symptoms of osteomyelitis. The diagnosis from purely inflammatory conditions and from other tumors and cysts can usually be completed by the x-ray picture which shows a cavity in the bone divided by fine bony trabeculae into numerous compartments. Sometimes in the more solid form histologic examination is necessary in order to differentiate the growth from sarcoma.

**Treatment**—In early cases in which the tumor is small and surrounded by well defined bony walls it is sometimes possible to obtain a cure by enucleation and curettage from within the mouth followed by implantation of radium. If the tumor is large with irregular extensions into the surrounding bone or perforation into the soft tissues complete resection should be the initial treatment. Of sixteen patients treated by the writer, four are believed to be well after conservative enucleation repeated several times in one case. Two patients are apparently well after a second conservative operation followed by implantation of radium. In four cases complete resection with loss of continuity of the mandible was the initial treatment with complete cure. Six patients after conservative operations have finally come to radical resection with apparent cure.

**b Dentigerous Cyst.**—The dentigerous cyst takes its name from the fact that it bears a tooth and forms a hollow swelling usually filled with clear straw colored fluid and having a partially or fully developed tooth attached by its root portion to the wall of the cyst with the crown projecting into the cavity. There is a lining membrane the inner layer of which is of epithelium derived from cells of the enamel organ. These cysts are usually first noticed about the period of eruption nearly always in con-

nection with the permanent teeth. Any tooth may be involved most commonly the canine and then the mandibular third molar.

**Symptoms and Diagnosis**—There is a gradually increasing swelling of the jaw bone usually involving the outer plate especially. Later the bone is thinned giving the characteristic parchment or celluloid feeling. The absence of a tooth from the series is a point of great significance. Suppuration may occur. The x-ray picture shows a clear area indicating absence of bone with well defined margins containing the unerupted tooth.

**Treatment**—The treatment consists in complete removal of the cyst capsule through an incision in the gum together with extraction of the unerupted tooth. The bone cavity soon fills in by granulation.

**c Dental Root Cyst or Radicular Cyst**—The dental root cyst is by far the most common form of cyst which develops about the jaws. It nearly always occurs as a sequel to chronic inflammation about the root apex of a tooth as a result of infection following death of the dental pulp. Cysts of this type therefore are most commonly found in adults and in connection with the roots of pulpless teeth. The responsible tooth may have been removed several years previously yet the cyst may continue to grow in the edentulous part of the jaw. The epithelial lining of the cyst is believed by most writers to be derived from the paradental epithelial cell rests of Malassez which are remnants of the cells of the outer layer of the enamel organ persisting normally in the adult dental periosteum. The wall of the fully developed cyst is made up of a dense fibrous capsule lined generally with several layers of squamous or cuboidal epithelial cells. The material in the cyst cavity may be the consistency of butter or it may be a clear straw colored fluid. Secondary infection may convert the contents into pus. These cysts vary in size from that of a small pea to that of a hen's egg. In the maxilla they may encroach on the maxillary sinus or the nasal fossa but they rarely break into these cavities. By extension a cyst may gradually involve the roots of adjacent teeth causing secondary pulp devitalization.

**Symptoms and Diagnosis**—Small cysts may cause no symptoms whatever the diag-

nosis being made by roentgen ray examination of the apical region of a pulpless tooth. This will reveal a clearly outlined area with sharply defined margins. Larger cysts cause a bulging of the bone about the apex of a pulpless tooth usually labially or buccally or in a location from which a tooth has been lost. The maxillary second incisor is the most frequent seat of development. If rupture into the mouth has occurred there will be a discharge of clear fluid or pus from time to time. There is usually no pain. Cysts that have not discharged fluid must be carefully differentiated from sarcomatous or other solid tumors. Close examination of the roentgenogram will usually make the distinction. In case of doubt needle puncture under aseptic precautions will establish the diagnosis. The x-ray shadow of the cyst may overlap the shadow of the roots of adjacent teeth. Here it is important to test these teeth for pulp vitality. If they are devitalized the success of treatment of the cyst may be interfered with by persistent infection from these teeth. On the other hand if pulps are found to be vital needless sacrifice of sound teeth will be avoided.

**Treatment**—The practice of simply making an incision into the swelling to provide drainage is to be condemned. This never gives permanent relief and usually introduces infection into a previously sterile region and by the formation of adhesions of the overlying mucous membrane renders radical operation more difficult. The responsible tooth if still present usually must be extracted and any secondarily involved teeth should be removed at the same time. The cyst itself should be treated by shelling out the entire epithelial lining and allowing the bone cavity to fill in by granulation. Small bone cavities may be allowed to fill with aseptic blood clot and may be closed over by suture of the gum flap.

**Calcified Dental Anomalies**—These are masses of calcified dental tissue usually replacing a normal tooth which consist of a disordered conglomeration of enamel dentine and cementum and sometimes masses resembling misshapen teeth. The mass may be unerupted or erupted. These growths may be discovered at any age and are frequently not recognized until supervening infection causes symptoms of osteomyelitis when the

hard masses are often mistaken for necrosed bone. They may be found in either jaw but more often in the lower and generally in the molar region. The x-ray picture will always reveal the nature of the condition. If a fistula is present and a probe is passed the hard dense character of the tissue is felt to be quite distinct from that of bone.

**Treatment**—If acute symptoms of infection are present with swelling, redness and edema of the tissues of the face and suppuration from the bone early treatment should consist in incision and drainage. After the acute symptoms have subsided the growth should be removed usually from within the mouth after some of the surrounding bone has been cut away sufficiently to liberate the mass.

**Metastatic and Secondary Growths**—**Carcinoma**—When carcinoma involves the jaw bones it is usually a direct extension from a primary growth of the oral mucous membrane. Occasionally, it may occur as a true metastasis from cancer of the breast or some other primary source just as other bones of the body are affected in this way.

**Thyroid tumors** both clinically benign and malignant occasionally metastasize to bone among them the jaw bones. The writer has reported a case of metastasis to the mandible of an apparently benign adenoma of the thyroid which had been removed almost eight years previously.<sup>3</sup> In the presence of an otherwise unexplained swelling bearing the characteristics of a tumor or cyst of the mandible the possibility of a metastatic growth should be considered.

**Miscellaneous Group of Conditions Resembling Tumors**—**Torus palatinus** an exostosis in the region of the median palatine suture of the maxilla presents an oval usually smooth but sometimes nodular hard swelling in the roof of the mouth. To the uninitiated this may be mistaken for an osteosarcoma. The torus palatinus is found normally as a developmental condition in a considerable percentage of persons; it undergoes no changes in size over a period of many years and causes no pain. Most persons are unaware of the presence of the growth. It demands surgical treatment only when the overlying soft tissues become irritated by rubbing or when the swelling interferes with the proper fitting of an artificial

denture. In such cases it can be removed with a chisel after the overlying mucoperiosteum has been dissected back.

Similar excrescences or *exostoses* are frequently found beneath the gum on the lingual aspect of the mandible in the premolar regions and also around the tuberosities of the maxilla. They are not progressive in growth usually give rise to no symptoms and require removal with a chisel only when they interfere with an artificial denture.

*Osteitis fibrosa cystica* may occur in the jaw bones especially the mandible producing localized or generalized areas of decalcification alternating with increased density. The diagnosis is established definitely on finding clinical and roentgenologic evidence of similar conditions in other bones and a disturbed calcium metabolism. The treatment is that of the general condition removal of the parathyroid tumor if found and symptomatic local treatment.

*Osteitis deformans* or Paget's disease is occasionally seen in the upper jaw where its manifestation is termed *leontiasis ossea*. In the maxilla a hard smooth swelling covered by normal gum tissue is seen in the region of the molar and premolar teeth. Later the swelling may be seen externally giving rise to the characteristic leonine features. The x ray plate usually reveals consolidation of the facial bones and sinuses with a peculiar thickening and mottling of the cranial bones. The etiology and the cure are unknown.

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## XX. THE NECK

### DEVELOPMENTAL ANOMALIES OF THE CERVICAL REGION

#### Classification and Synonyms:

##### A Midline

- 1 Sublingual inclusion cysts
- 2 Submental inclusion cysts
- 3 Thyroglossal cysts median cervical cysts
- 4 Thyroglossal fistulas and sinuses median cervical fistulas

##### B Lateral

- 1 Lateral cervical cysts, branchiogenic cysts, embryonic thymic cysts
- 2 Lateral cervical fistulas and sinuses, branchiogenic fistulas, embryonic thymic fistulas
- 3 Cystic hygroma
- 4 Lymphangioma
- 5 Hemangioma

#### MIDLINE AND LATERAL CYSTS AND FISTULAS

Incomplete or faulty development of the cephalic portion of the human embryo is believed to result in a variety of anomalies which become evident in childhood or adult life in the region of the neck. These anomalies may take the form of cysts, fistulas and sinuses or solid cell rests. They may be situated in or near the midline or may be lateral, and they may be found anywhere between the mandible and the sternum. These anomalies have been of great interest for over a century and hundreds of contributors have added to our knowledge of them. Attempts at classification have been anatomic, pathologic, embryologic and regional. None has been completely satisfactory, and efforts to simplify the subject have generally made it more confusing. The clinical recognition of these anomalies is generally not difficult and the treatment is fairly well standardized. The pathogenesis of the different varieties, however, is on less firm ground.

**Embryology.\***—During the last half of the third week of intrauterine life the human embryo shows more clearly than at any other period a series of five parallel bars or visceral arches (branchial arches) obliquely placed on each side of the cephalic portion in the region destined to become the upper part of the neck. These arches are separated from each other on the external surface by grooves termed visceral furrows (branchial clefts) and on the internal surface by evaginations called pharyngeal pouches. Normally the intervening "closing membrane" between each groove and pouch does not rupture, so there is no communication between the visceral furrows and the pharyngeal pouches. From the first arch are developed the upper and lower jaw, the malleus and incus from the second, the lesser cornu of the hyoid, the styloid process and part of the stapes from the third, the body and greater cornu of the hyoid from the fourth, the cuneiform cartilages and most of the thyroid cartilage, and from the fifth part of the thyroid cartilage and the corniculate arytenoid and cricoid cartilages. The first visceral (branchial) furrow or hyomandibular cleft obliterates except at its dorsal part which becomes the external auditory meatus. The remaining furrows disappear. Internally the first pharyngeal pouch gives rise to the eustachian tube and the tympanic cavity, the second forms no permanent organ unless a part is retained as the tonsillar and supra-tonsillar sinuses, the third by endodermal outgrowth forms the thymus and the inferior parathyroids and the fourth the superior parathyroids. The tympanic membrane represents the dividing membrane between the first pharyngeal pouch and the first branchial cleft. Normally the arches become joined together anteriorly, that is on the ventral surface of the embryo. The first and second arches grow more rapidly than the others and overlap them, forming an external groove called the cervical sinus or precervical sinus of His.

The thymus gland develops from two stalk-like diverticula which originate during the sixth week from the third and fourth pharyngeal (branchial) pouches. These diverticula grow caudad in the region destined to become the neck and fuse distally to become the thymic gland. During the few days in which these diverticula are patent they are sometimes referred to as the embryonic thymic duct. Normally they are obliterated by the seventh week.

The thyroid gland develops from an outpocketing from that portion of the floor of the pharynx whose location in later life is marked by the foramen cecum on the posterior portion of the roof of the tongue. This epithelial evagination is transformed into a stalked vesicle by the time the embryo has reached a length of 2.5 mm. This vesicle or diverticulum grows down.

\*The writer gratefully acknowledges the criticism of this section on embryology by Dr. L. B. Arcey, R. L. Rea, Professor of Anatomy, Northwestern University Medical School.

ward and backward from its point of origin as a tubular duct (thyroglossal duct) which bifurcates at its distal portion to form the thyroïd lobes. During its transitory existence the duct proper passes through or adjacent to a area which at a later time becomes the hyoid bone. Its distal end corresponds to the region which later becomes the pyramidal lobe of the thyroïd. This epithelial lined duct usually atrophies during the sixth week of fetal life. Remnants of an epithelial cord persist for a short time. The pyramidal glands are epithelial bodies arising from the posterior half of the third and fourth pharyngeal pouches.

**Etiology**—Deviation from the normal development just described may occur in a wide variety of ways. While definite proof is lacking the following theories are the most plausible. Incomplete union of the first two branchial arches in the midline may cause the formation of a midline *sublingual inclusion cyst*. If the failure of union is external the cyst will be epidermally lined (*dermoid*); if the failure of union is internal the cyst will be lined with mucous membrane. Faulty obliteration of the first and second branchial (ectodermal) furrows so that they close only at the external surface may result in inclusion cysts. The second cleft is the offender twenty times more frequently than the first and the results are epithelium lined cysts in the submaxillary, sublingual and submental regions. If the pharyngeal pouch fails to unite completely a pharyngeal diverticulum may develop or if it unites on the pharyngeal surface only a mucous membrane lined inclusion cyst may develop. The ultimate location of these cysts may be the same as those of external origin. The lining of the cysts is generally either ectodermal or endodermal. The probability that it includes both germ layers is small since the branchial furrows and pharyngeal pouches rarely communicate but are separated by a mesial plate. Failure or complete obliteration of the embryonic thyroglossal duct may leave (a) *midline cysts (thyroglossal cysts)* occurring anywhere on the pathway from the foramen cecum through or past the hyoid bone to the pyramidal lobe of the thyroïd; (b) *midline fistulas or sinuses (thyroglossal fistulas)* which may open internally or externally and end blindly or actually may be continuous from the skin of the neck to the foramen cecum; or (c) rests of thyroïd tissue anywhere along the temporary thyroglossal

pathway (Fig. 445). Failure of obliteration of the first and second clefts or possibly of the thymic evagination from the third pharyngeal pouch (embryonic thymic duct) may give rise to inclusion cysts in the lateral portion of the neck which occasionally may be moved toward the midline by growth or a fistula may form a communication from the pharynx near the tonsil to the skin of the lateral portion of the neck. The existence of this complete fistula presupposes the breaking through of the embryonic membrane separating the pouch from the furrow and may come about through an embryonic perforation or a postnatal infectious process. If the external opening is below the hyoid bone some writers think that the embryonic

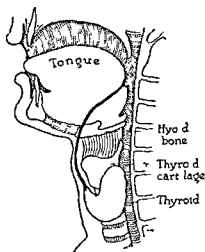


Fig. 445.—Diagram showing course and relations of the embryonic thyroglossal duct. Fistulas, cysts, or thyroïd remnants may involve any portion of the tract.

thymic duct is concerned it is possible that in these cases the transitory lateral thyroid tissues or the cervical sinus may play a role. The parathyroids may be concerned in the formation of lateral cysts. Other congenital anomalies are the congenital fistulas of the ear auricular appendages and congenital skin growths on the side of the neck. A congenital fistula of the neck communicating with the middle ear has been reported (Druss and Allen).

**Symptomatology and Pathology**—The median anomalies particularly the thyroglossal variety are more common than the lateral ones; moreover they are more common in women than in men and appear more frequently in the first two decades than later

in life. The cysts may become apparent at a very early age but more commonly in early adult life as rounded fluctuant swellings at the base of the tongue beneath the tongue in the midline of the neck below the hyoid bone in the subaural and submandibular regions or in the upper lateral portions of the neck. The growth of the cysts may be interrupted by periods of quiescence. The cysts may rupture spontaneously, generally externally; they may be incised by the surgeon under an erroneous diagnosis or they may become infected hematogenously and require opening. Once the cyst has ruptured a non-healing sinus develops which becomes secondarily infected. Such a sinus may open internally into the pharynx but also externally on the skin of the neck. Occasionally a complete fistula will exist between the pharynx and the skin of the neck. The external opening may appear years after birth and is generally just anterior to the sternomastoid muscle at any level but most commonly in the lower third of the neck. In the complete fistula food may work its way from the mouth through the fistula and be discharged on the surface of the neck. A case of bilateral complete fistulas has been reported. A purulent discharge may occur externally or internally and may vary in amount at different times. These sinuses can act as foci of infection and be a detriment to the general health. When the cysts are large they may become objectionable because of their pressure on adjacent structures or because of their appearance. They may be the source of a carcinoma. The thyroid rests may become important functionally if the normally situated thyroid is underdeveloped.

Histologically the lining of the cyst or fistula may be a derivative of the ectoderm or the endoderm but both embryonic layers are occasionally thought to be present in the same cyst or fistula. In the latter event we must believe that an embryonic perforation existed between the pharyngeal pouch and the branchial cleft. The contents of the cysts vary from clear serum to thick sebaceous material according to the character of the wall. The contents of the cysts and the discharge from the fistulas may be mucoid or purulent.

**Diagnosis**—All fluctuant cystic swellings of the cervical region may be regarded as possible developmental anomalies. When

they are inflamed and filled with pus their cystic character may be difficult to recognize. The abscess may rupture internally and burrow along the fascial planes of the neck. The embryonic cysts may be distinguished from sebaceous cysts in that the latter are attached to the skin and are superficial to the muscles. Lipomas are softer and generally present the *signe de peau d'orange*. Softened tuberculous lymph nodes or inflammatory adenitis may present considerable diagnostic difficulty. Tubercle bacilli have been found in branchial cysts. Branchiogenic carcinoma may be difficult to distinguish from metastatic carcinoma of the lymph nodes. Cystic hygromas are situated lower on the neck generally just above the clavicle.

The diagnosis of fistula may be facilitated by roentgenography after the injection of substances opaque to the x-ray (such as lipiodol) diluted half and half in liquid paraffin with closure by purse string suture after injection (Bailey) or by the external injection of bitter substances to see if they may be tasted or of methylene blue to see if it appears in the throat. Traction on the skin may demonstrate the cord like prolongation of the fistula. The rising of the fistula with deglutition is said to signify that the fistula is complete. Cysts may be aspirated and injected with substances opaque to the x-ray but they should be reaspirated afterward. Branchiogenic cysts may be found in the parotid gland. Aspirated contents of a branchiogenic cyst may show cholesterol crystals. If there is a swelling at the base of the tongue it should be remembered that a cyst is thin walled and light colored whereas aberrant thyroid tissue is solid and dark red. When cervical cysts attain adequate size there may be symptoms of difficulty in phonation, deglutition or respiration.

**Treatment**—The treatment of cervical cysts and particularly fistulas by the injection of sclerosing agents although long tried has practically been abandoned. Radical extirpation of the cyst or fistula is regarded by most surgeons as the only method of treatment which offers a chance of certain cure. This at times may be a formidable operation and should be undertaken only in a hospital operating room. The incision should be transverse in the case of a midline fistula and oblique and parallel to the skin creases

in the lateral ones. Bailey uses two transverse incisions, one above the other in lateral fistulas. Injection of the fistula with molten paraffin or methylene blue will aid in the excision. Where a thyroglossal fistula passes through the hyoid or is intimately connected with it, about  $\frac{1}{4}$  inch of the bone should be removed and the cut ends approximated. Above the hyoid bone, no attempt is made to isolate the tract, but the duct and tissues around it are corrod out through the muscles of the tongue to the foramen cecum.



Fig. 440.—Shows excision of fistula and tract and its relations. Clamp on end of fistula should be used to close the tract to prevent escape of fistula contents. Multiple transverse incisions are preferable (Holman).

(Sistrunk) The tissues for  $\frac{1}{4}$  inch around a lateral fistula should be removed and the wound should be drained (Fig. 440). The pharyngeal end of a complete fistula may be inverted into the pharynx and the fistulous tract closed by suture. Where access to the cyst is difficult the sternomastoid muscle may be divided. Preliminary aspiration is thought by some to facilitate excision of a cyst. In some of the cysts which are lined by mucous membrane the cyst wall may be very friable and difficult to remove. If such

wounds are packed with gauze the cyst wall may come out when the packing is removed. Pemberton followed 261 of 293 patients on whom operations for cysts, sinuses and fistulas of the thyroglossal duct had been performed and found only 4 recurrences.

### CYSTIC HYGROMA

(*Hygroma Cysticum Colli Cystic Lymphangioma*)

Anomalous development of the lymphatic system is probably the origin of the lymph cysts of the neck in infants and young children. At least part of the lymphatic system begins in two large jugular sacs situated on each side in the region of the junction of the internal jugular and subclavian veins. From this source lymphatics grow distally by budding. The careful studies by Goetsch indicate that cervical hygroma originates from sequestrations derived from the primitive jugular lymphatic sacs. These lymphatic rests retain their embryonic power of irregular growth and therefore may reach almost unlimited size. Although benign, these tumors may invade and destroy adjacent muscles or other tissues. They are multilocular and the thin walled cavities are lined with endothelium similar to that found in lymphatic spaces. These cysts may become secondarily infected.

Cystic hygroma is uncommon. Half the cases are noticed at birth and 90 per cent by the end of the second year (Gross and Goeringer). However, cystic hygromas may appear in adult life. They are generally found in the neck at the lateral border of the sternomastoid just above the clavicle. They may grow between the clavicle and ribs down into the axilla, up the neck or into the mediastinum and displace adjacent structures by their growth. The cystic hygroma is soft, elastic and painless. Though usually symptomless, advanced hygroma may cause difficulty by pressure on the trachea, pharynx or nerve plexuses.

Helpful in the diagnosis is the procedure of Duffy. He aspirates about 20 cc of the contents and notes its character. Without removing the aspirating needle he injects an amount of 15 per cent solution of sodium iodide equal to the quantity of fluid aspirated. A roentgenogram of the region is made at once and the resultant film gives an

accurate picture of the ramifications of the hygroma and is a help to surgical excision. In the differential diagnosis lipomas, brain cysts, lymphangiomas and aberrant thyroid tissue must be considered.

The treatment of choice is surgical excision. This may be facilitated by preoperative treatment with radium which is said to make the cysts smaller and in at least one case has effected a cure. The operation is both dangerous and difficult because of the proximity to the great vessels and important nerves and because of the difficulty in removing all the lining of the cyst. The task is a particularly hard one when the cyst extends into the thorax. Gross and Goeringer found no recurrence after surgical excision in 22 cases followed one to thirteen years. Good results were obtained by Watson and McCarthy in 4 of 7 cases by aspiration and injection of 1 to 3 cc. of 5 per cent sodium morrhuate solution. This method may be hazardous however because of the danger of introducing the sclerosing solution into the general lymphatic system. X-ray and radium should first be tried in the more difficult cases. In 4 of 7 cases in which x-ray treatment was employed Hodges, Snead and Berger obtained excellent results.

### LYMPHANGIOMAS OF THE NECK

Lymphangiomas of the neck are probably congenital and are thought to be neoplastic structures arising from the early capillary lymphatics. In the *simple type* the involved lymphatic vessels are similar to their normal neighbors and the tumor appears on the face or neck as a low, partly compressible swelling. In the *cavernous type* there are large endothelium lined lymph spaces with increased fibrous stroma; the tumor is firmer and may involve the skin alone. In the *cystic type* there is an accumulation of vesicle like cysts and the tumors which are generally larger are found on the neck, upper chest and axilla.

Lymphangioma is generally a disease of infancy or childhood and the chief symptom is swelling. The treatment in the majority of cases according to Semken is by irradiation. The firmer cavernous type of tumor may be excised but the excision may be very difficult if the lymphangioma has developed ramifying processes.

### HEMANGIOMA

#### (Angioma)

The term *angioma* is applied to a lesion characterized by a new growth of the blood vessels. In *telangiectasis* on the contrary there is merely a dilatation of pre-existing vessels. The commonest type of angioma is the *nevus vasculosus* or capillary nevus. It begins at birth or shortly after and varies in color from red to purple. It may occur on the neck as well as other portions of the body. The *port wine stain* (birthmark, *nevus flammeus*) is less common. It is red, violet and may cover large irregular non-elevated areas of skin. The *cavernous angioma* is a lobulated bluish mass which may be superficial or deep seated and even invasive in character. Application of carbon dioxide snow is a satisfactory treatment for the vascular nevus although some require x-ray or radium treatment. There is no satisfactory treatment of port wine stains. The *angioma cavernosum* may be treated with radium. According to Watson and McCarthy the treatment of choice for hemangioma at the Memorial Hospital, New York (with the exception of superficial capillary lesions and large inaccessible tumors) is injection with 5 per cent sodium morrhuate solution.

### BLOOD CYSTS

Blood cysts may be either true or false. The former are thought to be due to embryonic arrested development, simple venectasia or isolated varices which are gradually shut off from the parent vessel. They may or may not communicate with the vein. The false blood cyst may develop from a hemangioma. The diagnosis generally is not difficult. The treatment is excision through a wide incision and careful attention to hemostasis. (See section on Blood Cysts.)

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## WOUNDS OF THE NECK

Fractures, dislocations and injuries of the spinal cord are not considered in this section except to state that the cord may be affected by a penetrating wound between vertebral arches from the posterolateral region of the neck.

**Anatomy and Pathology.**—The covering of the neck in its anterior and lateral parts consists of skin, subcutaneous tissue, platysma and a superficial layer of deep fascia. Beneath this layer of deep fascia the fascia forms the carotid sheath and the compartments which envelop the viscera. These open freely below into the mediastinum. Exudate under pressure thus tends to spread downward either before or after infection has become advanced in the neck itself. The neck is tightly packed with numerous lymphatics, blood vessels, nerves, viscera and muscles. The vessels are large and the many nerves important. Some of the neck viscera are hollow, and if they are perforated, they predispose to infection of the surrounding structures and tissues and lose their normal

functions. The proximity of the mouth, pharynx, esophagus larynx and trachea adds to the seriousness of neck injuries because of the danger of infection and loss of function. Injury may cause aspiration into the bronchi of blood, secretions and exudate, resulting in pneumonia and lung abscess. Hemorrhage is the most common and the most serious feature of wounds of the neck. Next in importance to control of hemorrhage is the prevention of infection while the hemorrhage is being controlled. Infection from without is serious, but infection from an open viscus doubly complicates the situation. The profusion of lymph vessels in the neck pours lymph into the open spaces affording an added culture medium.

Injuries of the nerves in the neck are rarely vital, yet paralysis of the laryngeal nerves may weigh heavily against a patient struggling with respiratory embarrassment with its attendant aphonia. The most serious effect of injury of the vagus is paralysis of the recurrent laryngeal nerve. Stab wounds in the suprasternal region and forcible depression of the shoulder may result in permanent damage to the brachial plexus by severance or by stretching. Injury to the solid viscera is rarely important except that the thyroid gland may bleed profusely. A salivary fistula usually heals spontaneously. The parathyroid glands are rarely injured. Injury to the thoracic duct is uncommon, being more frequent in surgical dissections than in accidental wounds. Its large tributaries are cut more often than the duct itself. After days or weeks of leakage, the wound usually closes. The leakage is clear or milky, depending on food ingestion. Fat foods should be avoided.

**Etiology.**—It is probable that more accidents to the neck occur during operations than in ordinary life, but in the former the hazard of infection is less. The commonest surgical accidents are hemorrhage from large veins and damage to nerves, the nerves most commonly damaged being the accessory and the recurrent laryngeal nerves. Some writers emphasize the danger of air embolism, but in his experience with many large hemorrhages of veins the writer has never seen it.

Injuries of the neck, exclusive of the spine, are infrequent. In seventeen years there were treated in the Presbyterian Hospital in

New York only twelve fresh anterior or lateral accidental wounds of the soft parts. Three were cases of attempted suicides. There were four wounds of the back of the neck—all contusions. While it is admitted that probably all such diagnoses have not been recorded, these figures indicate a low incidence. In the large city-owned hospitals, especially in the congested districts, these wounds are more numerous.

War wounds of the neck are rarely duplicated in civil life. They are characterized by much destruction by serious infection and by the presence of foreign bodies. Bayonet wounds correspond more closely to some of the wounds of civil life. Whale and Ramsay and others give excellent descriptions of war wounds of the neck and of their management.

**Symptomatology.**—Severe contusion on the side of the neck is shocking (a blow popular with pugilists) and a large hematoma may result. A serious contusion may rupture the larynx, trachea, or esophagus, or damage the spine. Suffocation from displacement or by a large hematoma may occur. The common features of obstruction to breathing are hemorrhage into the trachea with cough, hoarseness, dysphagia, and emphysema. Strangulation is a form of contusion. If the patient survives, the features mentioned are to be kept in mind. The commonest incised wound of the neck is probably that of the attempted suicide. These wounds usually lie transversely across the upper part of the neck, and as they are usually made with the chin up and by the right hand, they extend more into the left than into the right side of the neck.

The anterior transverse wounds may be between the hyoid bone and the mandible. If the hyoglossus and genioglossus muscles are divided, the tongue drops back and causes respiratory obstruction. It is important to hold the tongue forward and to suture it in its forward position. An incised wound may enter the pharynx and damage the epiglottis and cartilages. While a wound may sever the trachea, it may not reach the large vessels which lie relatively posteriorly and are protected in part by the sterno-mastoid muscles. Profuse bleeding may occur, however, from the anterior vessels and from the thyroid gland. The recurrent laryngeal nerve may be divided. Incised

wounds tend to gap, and sometimes the platysma muscle acts to roll in the edges.

The term cut throat applies to anterior and anterolateral incised wounds of the neck. The immediate dangers of anterior wounds are hemorrhage and asphyxia. Hemorrhage may cease as blood pressure falls, only to recur on motion or manipulation. With a deep wound it must not be assumed that because bleeding is not active, it is securely arrested. Investigation is essential to assure control of obscure bleeding points. Asphyxia may be caused by the cartilage by the infolding of cut tissues, by a clot in the larynx or trachea, or by retraction of a completely severed trachea. The secondary dangers of an anterior wound are edema of the glottis, laryngitis, tracheitis, bronchitis, pneumonia, lung abscess, suppuration in the neck extending to the mediastinum, secondary hemorrhage, aphonia, and dysphagia. In the neck as elsewhere, a suppurative process usually implies an infectious thrombophlebitis of the accompanying veins and possible bacteremia. If the patient survives the hemorrhage, asphyxia, and shock, the commonest causes of death are pneumonia, mediastinitis, and bacteremia. Unrelieved edema of the glottis may be fatal. If conservative treatment does not allay a developing edema, tracheotomy can be performed.

Lateral incised wounds of the neck occur in fights and homicides and, if deep, may be the cause of serious hemorrhage and occasionally of arteriovenous or simple aneurysm. Lacerated wounds, both in war and in civil life, are most prone to infection. This is explained by the greater area of tissue contamination, the locking off of deep tissue spaces, the greater damage to the circulation of the affected tissue by the original trauma, the poorly supplied shredded parts, and the actual destruction of tissue which sloughs and interferes with nutrition and predisposes to bacterial growth. Such a wound is also more susceptible to tetanus and gas-producing infections. It may contain foreign bodies which become buried under torn parts. Dog bites usually represent superficial punctured but occasionally lacerated wounds of the throat. Deep penetrating or punctured wounds of the neck by missile or knife are often rapidly fatal, either from immediate arterial hemorrhage or from extravasation.

of blood perhaps only from a vein causing early respiratory obstruction by pressure. The suprasternal region may be wounded by a downward stab causing damage to the brachial plexus the subclavian vessels the large lower neck vessels the thoracic duct and the lung.

**Visceral Wounds**—The serious dangers of wounds in the neck are hemorrhage suffocation infection pneumonitis irritation and secondary hemorrhage. Except for hemorrhage these dangers depend largely on the penetration of or the effect on the structures that are lined with mucous membrane. Infection from them is more serious and more difficult to control than infection through the wound from without. The serious results in the neck are edema of the glottis infectious thrombophlebitis with bacteremia and with possible extension to the intracranial veins mediastinitis and secondary hemorrhage. Most secondary hemorrhages (usually from veins) occur in wounds badly contaminated from the mouth or the pharynx.

Wounds involving the floor of the mouth and the pharynx are accompanied by foul infection leakage of saliva difficulty of feeding discomfort slow healing and ultimate deformity. Esophageal wounds are due either to instrumentation within or to lateral penetrating wounds of the neck. If feasible the esophagus should be sutured in two layers by an approach in front of or behind the sternomastoid muscle. The operative approach should be drained and not sutured. Fluids may be given through a nasal tube but gastrostomy occasionally is needed after severe injuries of the neck, mouth and throat. When the larynx or trachea is cut across there is a tendency for the two parts to separate. A forward and low position of the head and chin thus facilitates their approximation. If the larynx is badly damaged a temporary tracheotomy may be performed with subsequent careful repair of the larynx. Wounds affecting the larynx produce respiratory disturbance changes in the voice cyanosis and blood on coughing. Localization is established by pain tenderness and the history of the injury.

Wounds of the trachea vary in degree. If it is only partially cut across separation is slight and primary suture may be indicated. If the division is complete the lower cut end

may retract beneath the sternum or be drawn in at each effort of inspiration when soft parts cover the orifice. If conditions are suitable attempt at suture should be made; if not the lower orifice should be sewed to the skin and a long tracheotomy tube inserted. Reconstruction of the trachea may be attempted later. Examination of these patients should include endoscopic examination introral and bimanual examinations and x-ray views of the pharynx and trachea if conditions permit.

The clinical picture of respiratory obstruction consists of great dyspnea cyanosis anxiety pain aphonia dysphagia a rapid full pulse and often with it in a fresh wound hemorrhage and in a later stage infection. When respiration is embarrassed hemorrhage increases when it is free hemorrhage decreases. Every hospital should be adequately prepared for quick tracheotomy. Laryngeal edema is the bugbear in cases of wounds in the neck. An oxygen tent may be helpful.

**Treatment**—The general principles of wound treatment apply to the neck and are modified only by the local anatomy and physiology. The immediate demands are control of hemorrhage prevention of suffocation and prevention of infection. One must be prepared to cope with shock and exsanguination and to prevent pneumonitis. The administration of tetanus antitoxin often is advisable. Severe venous bleeding can be controlled temporarily by direct pressure and packing. Arterial bleeding from a good sized vessel may not respond readily to pressure. Severe arterial bleeding may be controlled by digital pressure on the common carotid artery backward and inward against a vertebra. This digital pressure may need to be continued by relays of assistants until operation.

Take for example the case of a patient with a severe cut throat injury who reaches the operating room about three hours after the occurrence of the accident with the hypopharynx cut open the epiglottis divided the breathing partly obstructed and the transverse wound gaping and filled with a tight pack of gauze temporarily controlling hemorrhage from the left anterior jugular and common facial veins and from the left facial or external maxillary artery. The nec



essary maneuvers may be enumerated as follows 1 Chloroform anesthesia has been a good agent in these cases but now probably is being largely supplanted by intravenously administered sodium pentothal or evipal combined with adequate airway 2 The skin is shaved cleansed and sterilized widely 3 The packing is removed slowly and replaced with more specific pressure or clamping as it comes out 4 The open viscus is adjusted so as to ease the breathing 5 The wound is enlarged if necessary 6 Gross foreign bodies are removed 7 Clots are removed and the wound is irrigated with normal saline solution without spilling any into the airway 8 The sterno-mastoid muscle is freed and retracted backward 9 The exact anatomy of the wound is carefully identified 10 Each vessel is slowly released clamped and ligated care being taken that the veins are ligated at each cut end and that the main artery that is affected is ligated 11 The epiglottis and the pharyngeal wall are sutured 12 The whole wound is again flushed with saline solution several gallons being used with considerable force 13 The muscles are sutured over the pharyngeal closure 14 If the wound is relatively clean with good hemostasis it may be closed loosely leaving in a soft rubber-dam drain but if badly contaminated and not dry no further closure is indicated Soft drains and a moist dressing then are applied If an anaerobic infection is feared or should develop daily zinc peroxide treatment of the wound should be used—provided the hollow viscera are securely closed

Before during or after the operation the larynx and trachea may be aspirated of blood and mucus Blood or plasma transfusions may be needed The after treatment includes elevation of the foot of the bed and the semi prone position of the patient so as to favor drainage from the trachea quiet relief of pain fluids given parenterally moist loose dressings and daily inspection and dressing of the wound In the prevention and in the treatment of wound infection the use of modern chemotherapy and of penicillin may be life saving

The essentials in the treatment of impending laryngeal edema (edema of the glottis) may be stated as follows preparation for emergency tracheotomy (but this operation

should be done sufficiently early to allow for a deliberate, careful technique under local anesthesia) cold moist compresses ice to such fluids parenterally quiet morphine with atropine and free drainage of the wound The question of the best position for the patient should be considered Elevation of the head and shoulders decreases congestion while lowering favors expectoration from the trachea which is apt to accumulate mucus below the narrowed glottis

The selection of the anesthetic is important for the patient with a serious injury or infection of the neck Irritation of the mucosa swallowing coughing struggling cyanosis congestion of the vessels increased secretion of saliva and of mucus all predispose to the spread of infection pneumonia edema of the larynx and hemorrhage While chloroform has its dangerous feature if it is cautiously administered it is a good anesthetic to employ in these cases Cyclopropane may prove to be the best The regional and local infiltration of novocain increases trauma and pressure obscures landmarks and is uncertain of success in the deep and complicated cases Ether by inhalation has obvious disadvantages Ether per rectum by the Gwathmey technique is an excellent anesthetic yet the induction is slow and an excitement stage is not infrequent Avertin even in full dosage would require supplementary inhalation anesthesia in many instances It is not needed with chloroform and besides the two together are dangerous Avertin with novocain does not lessen the disadvantages of novocain Nitrous oxide with oxygen might be used occasionally if limited to analgesia and if the cooperation of the patient is assured but for complete anesthesia and relaxation the necessarily closed method carries with it a relatively narrow margin of safety in the matter of cyanosis venous congestion and strain The question of direct laryngoscopy and of the passage of a tube into the trachea will arise in connection with these patients One must weigh the advantages of direct examination of sucking out accumulations from the trachea of intratracheal anesthesia (usually ether) and of insufflation against the disadvantages of hyperextension of the neck and of laryngeal trauma

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## ABSCESSSES AND TUMORS OF THE NECK

### DEEP CERVICAL ABSCESS

Abscesses are particularly likely to occur in the deeper structures of the neck owing to the abundant lymphatic drainage from infected or potentially infected areas in the mouth and upper respiratory passages. Oral hygiene has done much to diminish the number of these infections but the majority of cervical abscesses still arise from infected teeth and tonsils. In the past, the mortality from deep cervical abscesses has been unduly high—a mortality of 30 to 50 per cent being reported for such conditions as Ludwig's angina. This high mortality may be accounted for by several factors, chief among which is the anatomical peculiarity of the structures involved.

The importance of fascial planes in infections of the hands is now well established but the importance of fascial planes in the diagnosis and treatment of infections of the neck is not so well understood. The fascial planes of the neck form well defined compartments and infection confined within these compartments may so obscure the usual signs associated with the accumulation of pus that the diagnosis may be delayed beyond the optimum time for drainage. It may also render ineffectual drainage which in other portions of the body would be effective. Pus confined within these compartments may accumulate sufficient pressure to obstruct respiration. The fascial planes may be effective in directing pus into the mediastinum. If one considers the ease with which

infection may spread to the central nervous system via the lymphatics or large vessel or to the mediastinum or to the lungs and vascular system it is small wonder that infections of the neck may have an unusually high mortality. Early diagnosis with a thorough conception of the extent of the infection and the possible sequelae is essential if one is to avoid an unduly high mortality. This is rendered doubly difficult because the signs usually associated with the accumulation of pus elsewhere in the body may not be manifest with pus in the deeper structures of the neck. When the spread of the infection is limited to the lymphatics particularly the superficial lymphatics, palliative or expectant treatment may be safely employed. However when the deeper fascial compartments of the neck are involved such temporization may be fatal.

**Etiology.**—It was formerly thought that the rapid and fatal termination of many infections of the cervical region was due to the peculiar virulence of the infecting organism. While this is undoubtedly a contributory factor it has been repeatedly demonstrated that the same organisms in other portions of the body do not produce such violent manifestations. Almost all known organisms have at some time or other been described in deep abscesses of the neck. The majority of these abscesses are caused by a streptococcus which is frequently obtained in pure culture. Usually there is a mixed infection of streptococcus and staphylococcus. As Mosher has demonstrated the greatest single source of these infections is in or about the tonsils. Next in frequency are the teeth. Deep cervical abscesses have followed a great variety of injuries in or about the mouth.

**Applied Anatomy.**—The following brief résumé is based largely on the work of Mosher and is particularly pertinent to the spread of these infections of the neck. There are three fascial compartments in the upper part of the neck which are prone to be involved in the spread of infection and which are in intimate relation to the sheath of the carotid artery and internal jugular vein. Each has a simplified concept of considering these compartments as a triangle with the stem of which is the sheath of the great vessels. These compartments are the pretracheal, the submaxillary and the paraglossopharyngeal. One or all of these fascial compartments may be involved.

The paraglossopharyngeal space is a cone-shaped space with its base in relation to the skull and its apex the jugular

foramen and with the apex at the greater cornu of the hyoid bone. Medially it is in intimate contact with the superior constrictor of the pharynx and the tonsillar fossa. The posterior portion is bounded by the retropharyngeal space. Its lateral surface is in relation with the retromandibular portion of the parotid gland which is not covered by fascia. The internal pterygoid muscle also forms part of its outer border. The pharyngomaxillary fossa is divided into two unequal compartments by the styloid process with its attached muscles. Infection of this space constitutes over one half of the deep infections of the neck. Because of its position it may be infected from the tonsillar fossa, mastoid, retropharyngeal glands, parotid, molar teeth and nasal pharynx as well as by the invasion of pus from the parotid or submaxillary compartments. The intimate relation of the vessels which traverse this

cause of its position the carotid sheath may become infected from the parotid, submaxillary or pharyngomaxillary fascial compartments. The pharyngomaxillary compartment is, however, usually involved. Local signs are of little use in diagnosing infection of the carotid sheath or jugular thrombosis. Swelling and local tenderness over the vessels may be misleading as they are frequently caused by involved lymph nodes. The general symptoms indicating blood stream involvement such as chill and rapid elevation of temperature, are of more value. Blood cultures should be taken during and immu-

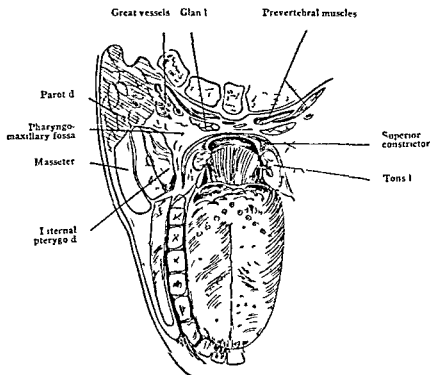


Fig 447—Cross section of the neck through the second cervical vertebra showing the pharyngomaxillary fossa (Courtesy of H P Mosher)

compartment is of extreme importance. Pus in the pharyngomaxillary fossa may cause the lateral pharyngeal wall to bulge inward. Bulging of the lateral pharyngeal wall may be mistaken for a peritonsillar abscess although careful inspection will reveal that there is little swelling of the tonsils *per se*. Its intimate relation to the internal pterygoid muscle and pterygomandibular ligament frequently results in trismus as an early sign. There may be pus in the pharyngomaxillary space without external visible evidence and it may result in jugular phlebitis. Occasionally pus extends from the parotid into the pharyngomaxillary space or vice versa. The submaxillary compartment will be discussed under Ludwig's angina.

**Carotid Sheath Infections and Jugular Thrombosis**—It will be readily seen that be-

diately after the chill. If this precaution is not observed blood cultures may be negative in the presence of jugular thrombosis if the thrombus is already well formed. This is probably due to the complete plugging of the vessel with occasional liberation of emboli. Repeated chills and fever with evidence of involvement of the pharyngomaxillary space indicate jugular thrombosis and call for immediate intervention.

**Treatment**—The successful treatment of a deep cervical abscess depends on early diagnosis and early adequate drainage. The external signs of pus are unreliable. Fre-

quent inspection of the pharynx with a careful consideration of the development of symptoms will lead one to suspect the accumulation of pus. The greater cornu of the hyoid bone may be taken as a landmark from which the various compartments particularly the pharyngomaxillary fossa may be explored. Blind incisions over swollen areas may be misleading, anatomical structures must be recognized and pus sought for in definite anatomical spaces which are frequently much deeper than anticipated. For deep abscesses of the neck which have a tendency to descend for instance those along the carotid sheath Gilloway suggests the performance of prophylactic mediastinotomy with gauze packing before drainage of the abscess proper. With this procedure mediastinitis is thought to be less likely to occur.

### RETROPHARYNGEAL ABSCESS

Retropharyngeal abscess is most common in early childhood. It is situated beneath the prevertebral fascia and thus may extend downward into the mediastinum or laterally into the pharyngomaxillary space involving the sheath of the great vessels. This retropharyngeal swelling may protrude so far forward that as it extends down the posterior pharyngeal wall it may eventually cover the larynx and obstruct respiration. Symptoms may begin with fever and a croupy cough at which time there may be extreme difficulty in making out the boggy swelling of the posterior pharyngeal wall. It may be followed by dysphagia and dyspnea. Lateral roentgenograms of the cervical spine may be extremely helpful in making a diagnosis. The abscess should be incised and drained orally.

### LUDWIG'S ANGINA

When a proper name is given to a previously unrecognized disease syndrome it may for a time serve the very useful purpose of calling attention to the significance of the syndrome but in the end it is likely to add to the general confusion as other signs and symptoms are added and a variety of unassociated conditions are inappropriately grouped under one heading. Ludwig's angina has proved no exception. The term is used to cover a variety of infections arising in the buccal cavity and related structures involving the floor of the mouth and extending from this to the neck and submaxillary regions.

There are many references in the older literature to similar conditions of the throat from Paulus Aegineta

down through the Greek and Arabian physicians including Hippocrates, Galen, Celsus, Aretaeus, Rhazes and others. Gothergill in 1739-1746 gave an account of "putrid sore throat." Gensoul of Lyons in 1830 published an excellent account of the disease. In 1836 Ludwig then a professor at Stuttgart in Wurttemberg published a report on gangrenous inflammation of the neck which report attracted considerable attention probably in part because Queen Catherine of Wurttemberg died of this malady. In 1837 Camerer gave it the name of *angina Ludovici*. Since that time most infections in the region of the mouth, pharynx and neck especially those that terminate fatally have gone under the name of Ludwig's angina. The French Surgical Society in 1899 was particularly concerned in a controversy between Volton and D'Arme as to whether Ludwig's angina should be recognized as a separate complete entity. The consensus of opinion at the present time is that it should and does constitute a clinical and pathologic entity and deserves special consideration.

**Etiology and Pathology.**—The problem of the high mortality and the cause of death has been paramount. The peculiar virulence and rapid progress of the infection have frequently led to the conclusion that a peculiarly virulent type of bacteria must be involved. Septic intoxication has frequently been held responsible for the fatal outcome. However as was pointed out by T. Turner Thomas in an excellent article "If septic intoxication is the essential cause of death then the especially high mortality of this condition must be explained by the presence of a rare and especially virulent infection. A variety of organisms have been found such as *staphylococcus*, *streptococcus pneumoniae*, *B. coli*, *gas bacillus* and all mixtures of the same. *Streptococcus* predominating. The high mortality has been shown to be due to the anatomical peculiarities of the region and to the extension of the phlegmonous inflammation to the larynx and lungs. In some of the fatal cases pneumonia and pleurisy have developed and a few patients have died of septic intoxication but in the majority there has been an interference with respiration. Dyspnea is noted in nearly all the fatal cases and if sudden death does not result from obstruction in the region of the glottis there is usually evidence of involvement of the lungs.

**Applied Anatomy.**—In order to obtain a better understanding of the mechanism involved in the spread of infection in Ludwig's angina the buccal cavity may be considered as a closed box. A detailed description is unnecessary as it is readily seen that the bony

structures such as the jaw teeth and palate sharply limit any swelling which occurs within the buccal cavity. Extension downward is limited by the diaphragm formed by the mylohyoid and the other muscles and ligaments attached to the hyoid bone which is relatively immovable. It is therefore obvious that when swelling occurs in the structures of the floor of

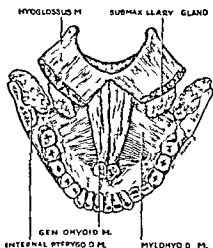


Fig. 418—Semiagrammatic sketch showing the diaphragm formed by the structures in the floor of the mouth.

the mouth or tongue, the buccal cavity is soon filled except for its posterior portion. As soon as swelling reaches this region there is obstruction of the respiratory passages. This mechanical feature alone undoubtedly accounts for a large percentage of the fatalities. A considerable number of the patients afflicted with Ludwig's angina die from a pulmonary infection which is probably explained by the extension and invasion of bacteria to the larynx coupled with the difficulties of respiration. The above anatomical features explain the mechanism of Ludwig's angina when the infection arises in the mouth. However, there has been some controversy as to whether the infection begins within the mouth or arises in the lymph nodes under the submaxillary triangle. Certainly it frequently begins within the mouth involving the structures above the mylohyoid muscle and later extends to the submaxillary triangle. This is accounted for by the fact that the opening along which the pus travels is formed by the submaxillary gland, the inner portion of which passes around the posterior border of the mylohyoid muscle thus connecting the neck with the floor of the mouth. Conversely, infection arising in the neck and forming pus in the submaxillary glands may extend by this route into the floor of the mouth. Occasionally pus accumulates nearer the midline in the submental region in which event it may lie either above or below the geniohyoid muscle but always underneath the mylohyoid.

**Diagnosis.**—An infection of the neck in the submental or submaxillary regions does not constitute Ludwig's angina. However, by extension from the submaxillary region

around the mylohyoid muscle to the floor of the mouth it may become Ludwig's angina. In Ludwig's angina the usual signs of the accumulation of pus, such as redness, fluctuation or localization are late. This is readily understood when it is realized that the infection is separated from the subcutaneous tissue by the mylohyoid muscle and dense fascial layers. However, there is frequently a brawny edema of the subcutaneous tissue. Careful palpation of the floor of the mouth may reveal evidence of an inflammatory reaction. Swallowing may be painful. Later there may be obvious evidence of swelling of the tongue and structures of the floor of the mouth. The disease may be subacute for several days and the general systemic manifestations may vary from moderate to violent. As the condition progresses, the symptoms may increase in severity out of all pro-

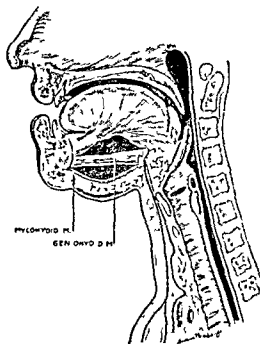


Fig. 419—Semiagrammatic sketch showing the location of pus in "Ludwig's angina" above or below the geniohyoid muscle. (Note the box-like compartment filled by the tongue and adjacent structures and the case with which inflammation extends to the region of the larynx.)

portion to the increased area infected and this usually indicates invasion of the larynx or lungs rather than septic intoxication.

**Treatment.**—Early diagnosis and early treatment are essential. The external signs of inflammation in the neck are of little use

and are more often misleading. One should not wait for fluctuation as a sign of pus or it will be too late. The pus is usually deep and cannot be palpated on the surface. It is possible to anticipate the diagnosis by frequent examinations for involvement of definite anatomical spaces especially if the floor of the mouth is watched for evidence of inflammation. It is important to locate the primary source of infection if possible as occasionally the disease has been aborted by adequate drainage of the primary lesion. Superficial abscesses may be drained through the mouth otherwise adequate drainage through the submaxillary fossa is indicated. The essentials of successful treatment are early and adequate incision with wide exposure and recognition of the structures involved. The necessity for immediate tracheotomy should be anticipated. General anesthesia may be dangerous owing to respiratory obstruction.

#### RECLUS' DISEASE

##### (Woody or Ligneous Phlegmon)

Paul Reclus in 1896 reported five cases characterized by a hard board like swelling of the neck thought to be due to a chronic inflammation involving connective tissue muscle and fascia. The etiology of this condition is still unknown although a variety of bacteria of low virulence have been grown from the yellow tinged fluid obtained on incision. While the cases reported by Reclus occurred in the neck similar lesions have been reported in various parts of the body. Some of these have been found to have deep underlying tumors such as carcinoma and sarcoma while others have developed into osteomyelitis. About 75 per cent of the patients recover although when the disease occurs in the neck there is a slightly higher mortality. Whether this condition deserves a place as a distinct disease entity is open to question. It usually runs a chronic course although some patients recover in a short time following incision. Small abscesses may form and should be drained. Since it seems to be impossible to distinguish this condition from certain slow growing carcinomas in the deeper structures the diagnosis should be regarded with suspicion until every effort has been made to rule out the other possible etiological factors.

#### BRANCHIOGENIC CARCINOMA

In a great majority of cases carcinoma of the neck is metastatic in the cervical lymph nodes and the primary source of origin is usually obvious. There is a second group of cases of carcinoma metastatic in the cervical lymph nodes in which it is extremely difficult to find the primary lesion. A careful search of the mouth nasopharynx and accessory nasal sinuses may not reveal the primary tumor. Not infrequently the tumor arises deep in the tonsillar crypt and extends to the neck the primary lesion remaining so small as to be unnoticed for a considerable period. Palpation of the tonsil in these instances may be helpful. However there is a third group of cases of carcinoma occurring in the neck in which removal of the tumor has resulted in permanent cure or in which no primary focus after years has been discovered. The general term cryptogenic carcinoma has been applied to these tumors and while it has been thought that the majority of them are of branchiogenic origin it is possible that they have arisen from some other aberrant tissue e.g. from the salivary glands or the thyroid. Space does not permit a complete discussion of the complicated anatomy of the branchial remnants and for a detailed description the reader is referred to the article published by Keith in 1909. Carcinoma may arise from the epithelium of any of the branchial remnants and there may be no definite histologic characteristics by which it may be identified. However as this is the least frequent origin of cancer in the neck all other possible sources such as a concealed primary growth in the oral cavity should be ruled out. Stout states that the tumors are commonly composed of squamous or transitional cells with little or no tendency toward keratinization or pearl formation but with a marked tendency to form masses with central necrosis of cells giving rise to cavities lined with tumor cells. The tumor generally starts deep in the neck near the bifurcation of the common carotid artery and either extends directly or metastasizes to the adjacent lymph nodes. A branchial cyst usually arises from the third branchial cleft or at the level of the hyoid bone. When it arises from the second branchial cleft it is situated below the mastoid and may project into the mouth.

of the thyroid gland and malignant disease of the mediastinal glands and by trauma to the recurrent nerves during or after thyroidectomy.

**Pathology**—In addition to the causative factors, loss of function of the abductor muscles of the vocal cords and interference with the respiratory function may be noted.

**Symptomatology**—The voice may be normal but the patient will speak as though breathless. The outstanding symptom is inspiratory dyspnea due to failure of the vocal cords to separate during inspiration. Expiration is normal.

**Diagnosis**—By mirror laryngoscopy the vocal cords are found in adduction. On inspiration there is no separation and only a slight drawing downward and inward of the edges of the cords. The cause of the paralysis must be determined and differentiated from cricoarytenoid ankylosis.

The prognosis is unfavorable as sudden death from asphyxia is always imminent. If paralysis is complete there is no hope of improvement; if partial as in syphilis there may be benefit from treatment.

**Treatment** consists of tracheotomy if there is obstructive laryngeal dyspnea. Removal of the cause rarely is possible. Anastomosis of the nerves in cases of injury has not been successful. The use of a one-way tracheal cannula is practicable. Ventriculo-cordectomy has not been successful. Submucous resection has been superseded by either mobilization and lateral fixation of the arytenoid cartilage (Lang) or arytenoidectomy and lateral fixation of the vocal cord (Kelly). These procedures are highly successful.

**Infection of the larynx** becomes of surgical importance when the inflammatory changes and associated edema produce stenosis and necessitate tracheotomy. Lack of space will not permit a detailed description of the causes or the pathologic changes observed.

**Acute Inflammatory Edema of the Larynx (Edema of the Glottis)**—**Definition**—Stenosis of the larynx resulting from acute inflammation.

**Etiology**—The causes may be acute laryngitis, acute infectious diseases, acute inflammatory processes involving surrounding structures, abscess of the larynx, acute

septic laryngotracheobronchitis, injuries or wounds of the larynx or neck, burns or scalds of the larynx, inhalation of irritating vapors, chondritis and perichondritis, chronic diseases or foreign bodies.

**Pathology**—The changes are those of the underlying cause together with inflammation and edema involving the submucous tissues above and below the vocal cords.

**Symptomatology** includes obstructive laryngeal dyspnea with disturbances of the voice and general systemic reactions. *Obstructive laryngeal dyspnea* is characterized by inspiratory indrawing of the soft tissues of the thoracic cage at the suprasternal notch, epigastrium and intercostal supraclavicular and infraclavicular spaces with restlessness, shiny gray pallor and increasing pulse and respiratory rates. Cyanosis occurs late and is a danger signal.

**Diagnosis**—The signs of obstructive laryngeal dyspnea are diagnostic. Inspection of the larynx, palpation of the neck, roentgen examinations, general systemic studies and the history are usually required in order to arrive at an etiological diagnosis.

The prognosis depends on the cause. The dyspnea can be relieved by tracheotomy.

**Treatment**—In simple cases inhalation of medicated vapors, the use of the oxygen tent and general medical measures may suffice. *Sedatives must be avoided*. If dyspnea is marked tracheotomy becomes necessary. This should not be delayed until an etiological diagnosis is made but must be promptly executed. *Tracheotomy* consists of incision into the trachea in the midline of the neck below the first tracheal ring, preferably below the second ring. General anesthesia is contraindicated. *Tracheotomy* should be performed early so that it can be carried out in an orderly manner. Delay is dangerous and commonly results in a poorly performed operation. So-called high tracheotomy is an improper operation which although life saving is commonly followed by chronic stenosis. The skin incision should extend from the thyroid notch to the suprasternal notch; the thyroid isthmus should be incised and ligated; two or three tracheal rings should be cut. The tracheotomic cannula should be of proper shape and size. The wound should not be sutured but left open. The after care consists of keeping the air

way open by wiping away coughed up secretions cleaning the inner cannula and aspirating secretions from the trachea through the cannula. With crusting of secretions bronchoscopy through the tracheostomic fistula may become necessary in order to keep the airway open.

**Non inflammatory edema of the larynx** as observed in cases of nephritis angioneurotic edema and passive congestion due to venous obstruction becomes of surgical importance only when tracheotomy is required to relieve obstructive laryngeal dyspnea.

**Chronic Stenosis of the Larynx (Cicatricial Stenosis of the Larynx)**—*Definition*—Narrowing of the laryngeal airway by cicatricial changes.

*Etiology*—The most common cause is improperly performed tracheotomy or improper after-care. Other causes may be syphilis tuberculosis injuries chondritis perichondritis and abscess.

*Pathology*—The normal structures are replaced by cicatricial tissue with narrowing of the airway fixation of the vocal cords and often loss of a part of the normal supporting cartilaginous framework of the larynx (Fig 450). If tracheotomy has been improperly performed a portion of the cricoid or thyroid cartilage may be lacking.

*Symptomatology*—The chief symptom is an inability to secure any or sufficient air through the normal airway. Voice disturbances vary from hoarseness to aphonia. There is an inability to decannulate.

*Diagnosis*—*Examination of the larynx* reveals a narrowing or obliteration of the airway the extent and degree being determined by direct laryngoscopy palpation of the neck and roentgen examination. Retrograde laryngoscopy and esophagoscopy may be necessary.

The *prognosis* is good if there is little loss of cartilage but months or years of treatment may be necessary to secure a good result.

*Treatment*—In moderate degrees of stenosis laryngoscopic dilation may be adequate. In marked cases surgery must be resorted to and consists of laryngostomy removal of sufficient cicatricial tissue to reestablish the airway and the use of some form of apparatus to maintain the airway during the process of healing. In the open method

a trough corresponding to the stenosed airway is maintained by the use of a dilating apparatus. When a satisfactory airway has been secured the fistula is closed by plastic operation. In the closed method the airway is reestablished a rubber tube is transfixed in the larynx with silver wire and the neck closed (Fig 450). The rubber tube is removed perorally after a number of weeks or months.

#### DISEASES OF THE TRACHEA AND BRONCHI (Exclusive of Neoplasms)

Injuries to the bronchi are rare and are usually associated with extensive pulmonary damage. Injuries to the trachea are more common falls blows or wounds of the neck being the common causes. The tracheal rings may be incised or fractured or the interannular membrane may be lacerated. Dyspnea is present depending on the degree of narrowing of the airway. If vessels have been injured there is hemorrhage. Empyema may result from laceration of the trachea. Pain on swallowing may be severe. The history with the local evidences of injury is usually diagnostic. Bronchoscopy may be necessary. The prognosis depends on the extent of the injury and the involvement of the surrounding structures notably blood vessels and esophagus.

*Treatment*—Hemorrhage should be controlled first. Tracheotomy is indicated for dyspnea. Incised wounds should be repaired with drainage. Cicatricial stenosis is treated by dilation or by tracheostomy performed as in laryngostomy.

**Infection of the Trachea and Bronchi.**—Simple catarrhal infections present no surgical problems. Chronic infections such as tuberculosis and syphilis are of surgical importance if stenosis results. Pulmonary suppurations namely *abscess* and *bronchiectasis* are of importance bronchoscopically particularly from a surgical standpoint (see section on Bronchiectasis and Lung Abscess).

#### FORGIVEN BODIES IN THE AIR PASSAGES

The lodgment of a foreign body in the larynx trachea or bronchi is a common accident. The most common cause is carelessness in holding objects other than foods in



the mouth. These are commonly aspirated with a deep inspiration when the person is laughing, coughing, sneezing, singing or talking. The pathologic changes depend on the character and location of the object, the length of sojourn and whether or not there is obstruction. Recent non-obstructing foreign bodies may produce no changes other than slight inflammation at the point of lodgment. Obstructing foreign bodies will ultimately cause suppuration and bronchiectasis. The initial or immediate symptoms are choking, gagging and coughing. The subsequent symptoms depend on the size,

non-obstructing foreign bodies may produce no symptoms, the initial symptoms being followed by a *symptomless interval*. The *asthmatic wheeze* is an important sign. If a foreign body produces partial bronchial obstruction, there is often an obstructive emphysema. In complete bronchial obstruction there is obstructive atelectasis. Partial obstruction is usually produced by nuts, seeds and shells that do not swell in the presence of moisture, whereas complete obstruction is produced by globular foreign bodies and vegetable seeds that swell when moistened.

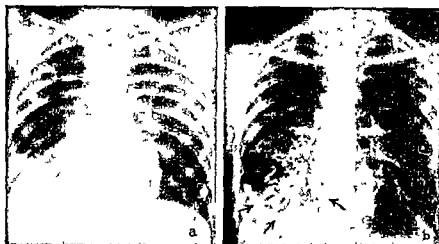


Fig 451.—A typical example of an obscure lesion of the chest requiring bronchoscopy as an aid in diagnosis. The patient, aged nine years, had been ill, with irregular fever, cough, slight expectoration and pain in the right side of the chest for about three months. The history was practically negative. By physical and roentgen examination the lesion was localized to the right lower lobe. The heart was drawn to the right (a). It was necessary to differentiate between bronchial obstruction with pulmonary atelectasis and bronchiectasis with pulmonary fibrosis. At bronchoscopy the bronchi were found patent and larger than normal. Roentgenograms made following the bronchoscopic instillation of iodized oil into both lower lobe bronchi revealed extensive bronchiectasis involving the lower lobe of the right lung with a normal left lower lobe bronchus (b). Lobectomy was recommended. (Films by Dr J T Farrell, Jr.)

shape and character of the foreign body and the point of lodgment.

**Foreign Bodies in the Larynx.**—The common symptoms are dyspnea and disturbances in the voice. There may be a cough and wheezing. Large, obstructive foreign bodies may produce asphyxiation.

**Foreign Bodies in the Trachea.**—Migratory foreign bodies produce paroxysmal coughing. An audible slap and palpatory thud may be elicited. Dyspnea and wheezing respiration may be present. If the foreign body is obstructive, there is commonly bilateral obstructive emphysema.

**Foreign Bodies in the Bronchi.**—Small

A history of initial symptoms of choking and gagging while holding something in the mouth and the occurrence of a wheeze are practically pathognomonic of the presence of a foreign body. With clinical and roentgen evidences of bronchial obstruction a positive diagnosis can be made in practically every case. In the case of a metallic object the roentgen finding should be conclusive. Over 98 per cent of foreign bodies can be safely removed. Peroral endoscopic removal is the only method worthy of consideration.

Peroral endoscopy, direct visualization of the interior of the trachea and larger bronchi, is possible by the use of specially

illuminated rigid hollow tubes. These are introduced through the mouth and serve as specula to draw aside structures that obstruct the view or bring them into the line of vision. The direct laryngoscope is a laryngeal speculum; the bronchoscope is a tracheal or bronchial speculum.

The smaller bronchial subdivisions cannot be entered bronchoscopically; much information may be secured, however, by palpation with forceps, by aspiration of secretion with the aid of straight and curved flexible

instrument in intratracheal insufflation and anesthesia.

*Instruments*—A special instrumentarium is necessary. Certain instruments are regularly used in the common procedures, while other instruments are required only in special cases. The normal air passages cannot be dilated beyond their normal caliber. It is therefore necessary to have special sized instruments for infants, children and adults.

*Training*—Acquiring skill in the use of endoscopic instruments can be secured only



Fig. 432.—Introduction of the bronchoscope. The patient is recumbent with head and shoulders extending beyond the end of the table. The head is supported by the left hand of the assistant. The mouth gag is in the left angle of the patient's mouth. The shoulders are supported by an assistant. The direct laryngoscope is held in the operator's left hand, exposing the larynx. The bronchoscope is held in the right hand of the operator, inserted through a laryngoscope and passed through the larynx into the trachea. As soon as the distal end of the bronchoscope has passed beyond the vocal cords the laryngoscope is removed. The bronchoscope has the latex cord and aspirating tube attached. An additional independent aspirating tube held by the nurse is ready for use.

tipped aspirating tubes and by the bronchoscopic introduction of opaque materials. Bronchocopy is the only method for the removal of foreign bodies from the air passages and it has also made possible outstanding contributions to the diagnosis and treatment of pulmonary diseases. Noteworthy among these are the early and positive diagnosis of bronchial carcinoma made possible by bronchoscopic removal of tissue for histologic examination and the bronchoscopic treatment of pulmonary abscess. In addition direct laryngoscopy plays an impor-

tant part in the diagnosis of laryngeal disease by educating the eyes and the fingers. As this cannot be secured on the living patient the fundamental principles are best taught on the cadaver. This should be supplemented by practice on the rubber tube manikin. When skill and proficiency have been attained experience should be secured on narcotized dogs so that the normal physiologic movements may be observed and studied.

*Anesthesia*—General anesthesia is not necessary and is often undesirable but patients are commonly given a preliminary

sedative. Immediately before the operation the larynx of the adult patient is cocaineized. In children however the use of cocaine is considered unsafe.

**Technic of Introduction**—The patient should be in the dorsally recumbent position with the head and shoulders extending beyond the end of the table. The head is supported by the left hand of an assistant who is seated at the patient's right with his right hand the assistant holds the mouth gag in the left angle of the patient's mouth. The shoulders are supported by a second assistant. The operator exposes the larynx with the direct laryngoscope held in the left hand with his right hand he then introduces the tip of the bronchoscope through the laryngoscope into the trachea (Fig. 45<sup>o</sup>). The laryngoscope is removed and bronchoscopy is done. It is not within the scope of this article to discuss the detailed technic of the various procedures involved.

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#### NEOPLASMS OF THE LARYNX

Neoplasms of the larynx may seriously interfere with the voice and the airway and by extension compromise the adjacent vital structures. The chief tumors arise on or near epithelial surfaces underlying and supporting tissues contribute relatively fewer and less serious new growths.

#### MAIGNANT TUMORS

**I. Carcinoma** is of outstanding importance. The intrinsic form usually advertises its presence by hoarseness that should lead to its diagnosis early enough to be curable in over 80 per cent of cases with a service-

able voice and a natural airway. When neglected, overlooked or temporized with, carcinoma of the larynx produces one of the most desperate end states to be seen in medicine.

**Etiology**—No specific agents have been implicated as important factors. A general predisposition plus some local irritation is favored here as elsewhere as the cause of cancer. Hot drinks and hot foods have some presumptive evidence for their role in post-cricoid cancer. Smoking which has a rather definite place in the development of lingual and oral cancer seems also to be of some importance here.

**Age**—Most patients with cancer of the larynx are past fifty years of age. The disease rarely occurs before forty but cases have been reported in the second decade of life.

**Sex**—Men are most commonly attacked although post-cricoid carcinoma occurs much more often in women and at the earlier age of thirty or forty years.

**Pathology**—a. *Intralaryngeal carcinoma* may be divided after Haugant into four groups which differ from each other in their origin, location, symptoms, relative malignancy, prognosis and treatment.

1. **Cordil tumors** comprise the largest percentage of laryngeal carcinomas and offer the most favorable outlook. The middle or anterior third is most often attacked. The lesion may be papillomatous, fungating, nodular or ulcerating with varying degrees of deeper infiltration. Since these neoplasms arise from flat pavement epithelium the majority are of relatively mature squamous cell type and of low grade malignancy though the anaplastic cell type occurs in a small percentage of cases. The neoplasm may extend above the surface or beneath the mucosa or it may deeply infiltrate the cord and adjacent structures. It grows slowly and spreads late because of two factors: one is the mature cell type and the other the scant lymphatics with few anastomoses and limited drainage of the tendinous cord structure and adjacent larynx. In time one or both cords may become infiltrated and fixed and cancer cells may spread beyond the cord region where their growth is much more rapid resulting in a ruthless attack on adjacent structures. The cartilages may become

eroded the larynx filled and the airway blocked. The cervical glands become involved first as separate hard nodules later as large fixed and even ulcerated and bleeding masses. Spread posteriorly involves the larynx and the esophagus and overruns the rim of the glottis into the hypopharynx obstructing the esophagus. The great vessels of the neck or their important branches may be involved. Distant or general metastases are rarely important before the terminal stage.

2 Subglottic carcinomas are relatively common are usually mature celled radioresistant and well advanced when diagnosed and are best treated by laryngectomy or hemilaryngectomy.

3 Cancer of the false cords or vestibule is more often embryonal in type and invasive, it early extends beyond the larynx and it responds fairly well to irradiation.

4 Cancer of the ventricle of Morgagni is rare. It usually is of hornifying cell type infiltrating and radioresistant and is best treated by laryngectomy.

*b Extrinsic carcinoma* of the larynx arises from the epiglottis the arytenoids or aryepiglottic folds or the upper or posterior surface of the cricoid or occurs as an extension beyond the larynx of a primarily intrinsic growth. Many of these have the essential character of tumors of the oropharynx. They are much more malignant in type as a rule of anaplastic or transitional cells they extend rapidly locally and give early metastases to the regional lymph glands. The airway and cords are involved later the food passages earlier than in the intrinsic group and in time the growth may fill the larynx lower pharynx and upper esophagus and may fix the glands and deep structures of the neck in one indurated even externally ulcerating mass.

Symptoms first arise from interference with the voice and respiration especially in the intrinsic form. Later they are due to involvement of the esophagus and the secondary effects of ulceration infection and regional nerve involvement. *Hoarseness* is early in intrinsic cancer and persistent becoming progressively worse. It is a warning not to be ignored while the condition is yet curable. Vocal fatigue and poor voice control precede or accompany hoarseness and

rest may temporarily lessen the dysphonia. Subglottic lesions may for a time only muffle the voice and in primarily extrinsic forms voice changes may be quite late. *Dyspnea* is a relatively late symptom but all too common is the first symptom leading the patient to seek medical attention. It may progress gradually but there may be acute respiratory difficulty due to a superimposed infection or edema. *Dyspnea* may be distressing and tracheotomy will be required in advanced cases. *Dysphagia* occurs late and only in extrinsic forms. It arises from obstruction or fixation of the esophagus and is most marked in the posterior forms. *Discomfort* may come early and there may be a feeling of sticking or a sense of a foreign body, but real pain is late rarely occurs in intrinsic forms and is caused by ulceration infection or nerve involvement. Not infrequently it is referred toward the ear of the affected side. *Cough* may occur from reflex irritation. Later it is due to esophageal obstruction with overflow of saliva or food into the respiratory tract. Symptoms of an advanced stage are palpable cervical glands cachexia loss of weight fetor oris hemorrhage and sepsis.

Diagnosis should not be difficult when the condition is once suspected. Other causes of hoarseness especially should be ruled out. Examination by laryngeal mirror or by direct laryngoscopy shows an uneven cord with a grayish rough nodular or dimpled surface or a papillomatous or infiltrating mass with the cord lagging or fixed if the disease is advanced. Biopsy should be performed under direct laryngoscopy but only when both the surgeon and the patient are prepared for the operative procedure which may necessarily follow. The importance of a correct diagnosis far outweighs the possible dangers of this procedure.

Carcinoma must be differentiated from chronic laryngitis and benign tumors and especially from tuberculosis and syphilis with which it may coexist. Benign tumor do not infiltrate rarely fix ulcerate only late if at all and run a simple course. Microscopic examination may be necessary to determine their type. Inflammatory lesions are usually not focal but diffuse are associated with sinus pharyngeal or systemic disease and improve under rest and proper

treatment Tuberculosis as a rule produces catarrhal thickening of the cords or shallow ulcerations and papillary hypertrophy in the interarytenoid space rarely involved in cancer and characteristic rounded or pyriform swellings over the cartilages The lesions are usually pale The condition may be painful and is associated with active pulmonary disease Syphilitic lesions are rarely sharply localized are hyperplastic or ulcerated and are darker They give positive serum tests and quickly respond to specific therapy especially iodides Leukoplakia of the larynx is usually a diffuse grayish thickening overlying the cords which occasionally can be differentiated only microscopically Sometimes it is a precursor of cancer

**Treatment**—Peroral removal of a very small growth with direct laryngoscopy or suspension can be accomplished with slight hazard and no important mutilation of the vocal apparatus Microscopic study however indicates that an intrinsic growth may infiltrate 0.75 cm beyond its apparent border and usually no less than that area of grossly healthy tissue should be removed For that reason peroral removal is not generally considered to provide adequate safety

**Laryngofissure** is the nearly ideal treatment in proper cases as it will effect a cure in over 85 per cent with a natural airway and a usable voice It should be performed in early intrinsic cases usually involving one cord away from its posterior border and without marked fixation The writer believes with St. Clair Thomson that its indications should be widened at the expense of somewhat greater safety because when it is successful it leaves the patient a nearly normal person for whom life may still hold full zest The same can hardly be said for laryngectomy Even growths with some fixation or involving the anterior commissure or partially subglottic may be so treated with reasonable hope of success if clinically and histologically of low grade malignancy

The technic is simple and the operative mortality below 1 per cent A midline incision is made from the hyoid bone nearly to the sternum through skin and fascia and so encounters no important bleeding A low tracheotomy is usually done and the larynx is entered exactly in the midline The wing

of the thyroid cartilage on the affected side is separated from its perichondrium and removed or it may be left with only the medial perichondrium separated The affected soft tissues medial to the cartilage including cord and ventricular band as far back as the arytenoid cartilage are resected Closure may be partial or complete A feeding tube may be required though frequently it is not necessary and the tracheotomy tube may be removed at once or after a few days

**Laryngectomy** is more likely to eradicate malignant disease than the simpler operations A limited number of surgeons have developed a technic that in selected series has reduced the operative mortality to 1 per cent and has given 74 per cent of five year cures The patient after operation must breathe through a tracheal neck fistula or a tube is subject to the added danger of respiratory disease and finds heavy labor difficult Often the patient learns to produce a useful buccal or pharyngeal voice or may do satisfactorily with an artificial mechanism

Briefly the technic of operation is as follows The skin and superficial fascia are divided in the midline The anterior strap muscles are pushed aside or divided the larynx is completely skeletonized and is divided intact from the trachea pharynx and esophagus and the defect is closed in layers Great care is taken to prevent aspiration into the trachea and abundant drainage is provided The tracheal stump is united to the skin A feeding tube is left in the esophagus for one or two weeks Meticulous after care and continuous nursing attention are required The operation and after-care have been much simplified by leaving the strap muscles in place removing the cartilage after elevation of the perichondrium and leaving the mucosa on the posterior wall of the cricoid This gives much easier closure usually without leakage or infection and a smoother convalescence

**Irradiation** has been again advocated on the basis of improved technic which may allow its administration without injury to the cartilages It may be given by high voltage roentgen ray well filtered and at a distance in frequently repeated small doses (Coutard) or by using similarly large amounts of well filtered radium (Berven), or by direct implantation of radium or ra-

don seeds after resection of cartilage. The best statistics of five year cures by these methods are under 30 per cent and it does not seem justifiable to the writer to so treat intrinsic carcinoma of the cords suitable for laryngofissure. Even laryngectomy seems preferable unless the growth has extended beyond the larynx or unless other conditions like age, diabetes or tuberculosis make operation hazardous or seriously reduce the patient's expectancy.

**II Sarcoma** occurs rarely in the larynx though previously it was diagnosed with relative frequency probably as a result of error in histologic interpretation. In the larynx sarcoma occurs in the more benign types especially fibrosarcoma. It also occurs in later age groups than sarcoma elsewhere and rarely metastasizes. Operative removal which follows that outlined for carcinoma should be relatively radical and has been quite successful.

### BENIGN TUMORS

Benign tumors of the larynx usually have an important effect on the voice and may seriously interfere with breathing. Nearly always they require destruction or removal.

**Pathology**—These tumors do not infiltrate the deeper structures or give local or distant metastases.

**A Papillomas** are perhaps the most important. Two types occur.

1 In adults they occur as single or multiple fibrous growths covered with piled up epithelium and appearing as grayish rough rounded wart like or even pedunculated masses. They spring from the cords or any part of the larynx and tend to recur repeatedly.

2 Papillomas in children somewhat resemble common warts in their histology, tendency to recurrence, auto-inoculability and tendency to spontaneous disappearance. They occur as numerous single or branching masses of piled up epithelium with a moderate fibrous stroma springing from the cords or any part of the larynx, trachea, bronchi or even the margins of a tracheotomy wound. They may occur as scattered growths or may completely fill the larynx as a grayish grape like mass.

**B Other benign tumors** include *angiomas* which may be globular or pedunculated.

They usually include much fibrous stroma and usually remain small. *Fibromas* are small soft smooth and red and usually arise from the cords. Some of these arise from granulomatous organization of hematomas which occur chiefly as a result of vocal trauma. *Lymphomas* may be benign and non-recurring but may be associated with a general lymphomatosis. *Adenomas* or *cystadenomas* may reach a considerable size in the larynx. *Myxomas*, *lipomas*, *chondromas*, *osteomas* and *neurofibromas* occur rarely. *Congenital* cysts are to be thought of in asphyxia of the newborn. Aberrant thyroid tissue does occur but is rare in the larynx. Hematomas, tophi, amyloid masses and edematous polypi may simulate tumors. Singer's nodes and contact ulcer granulations are reactions to vocal trauma.

**Symptoms**—First there is vocal disturbance with early huskiness, an unstable voice, easy fatigability, increasing hoarseness or even aphonia. Croupiness and cough are likely to be present with acute infections of the upper respiratory tract. Dyspnea may occur as a late symptom of obstruction and may be of acute onset as a result of edema or infection. If arising elsewhere in the larynx than from the cords, a benign tumor may attain a relatively large size without symptoms.

**Diagnosis** is made on the basis of the symptoms with the typical appearance on mirror examination or by direct laryngoscopy. Microscopic examination of tissue removed by forceps may be necessary for the final diagnosis. Benign tumors of the larynx are to be differentiated from each other from carcinoma and from chronic inflammations especially tuberculosis and syphilis. Again the microscope may be necessary for the final decision.

**Prognosis**—Usually these tumors are not dangerous to life if properly treated. Some as for instance papillomas may lead to death by asphyxia and the removal of others may seriously affect the voice or lead to laryngeal stenosis.

**Treatment** of benign tumors of the larynx should usually be surgical removal by snares or forceps used under guidance of a laryngeal mirror or by direct laryngoscopy. Rarely is laryngofissure required. Irradiation is the treatment of choice of lym-

phomas and possibly of some papillomas. Diathermy if used with great caution may be valuable. In any case great care is necessary not to injure the cords or cricoarytenoid articulation. Papillomas should be removed from the intact cords with cutting or cup forceps rarely with punch forceps. Very careful surgical diathermy tends to prevent recurrence though it may easily injure the vocal cords. In children radium in small amounts has been advocated for papillomas though its use has led to adhesions and stenosis. Roentgen ray likewise has been used in small doses well filtered. Sex hormone therapy sometimes produces striking remissions. Ultimate spontaneous recovery in children

is the rule so that measures radical enough to injure the airway or voice should not be employed. Tracheotomy should not be delayed when dyspnea begins with papillomas in a child as asphyxia may quickly supervene.

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## XXI. THE BREAST

### ANOMALIES AND INFECTIONS OF THE BREAST

The class of animals called *mammalia* is distinguished by the nourishment of the young by milk secreted by the breast. In human beings this organ especially in the female reaches a high degree of differentiation and is subject to extreme physiologic variations and many important diseases of surgical interest. For a clear understanding of these certain anatomical and physiologic facts are necessary.

The breast is embryologically closely related to the sweat glands and the differentiation from these is not so great but that certain epithelial tumors of the breasts have similar histologic characteristics. In particular the resemblance to the apocrine glands of the axilla is of significance in the derivation of the breast.

The first indication of the development of the breast is the appearance of the milk ridge—a bilateral thickening of the epidermis extending from the anterior fold of the axilla downward on the ventral surface of the thorax and abdomen as far as the groin. This is largely a proliferation of the cells of the corium which undergoes a process of nodulation indicating the future sites of the breast. In certain of the *mammalia* these nodosities are multiple but in man a single one occurs on each side in the thoracic region; the remainder of the Anlage disappearing. The epithelial thickening which makes up the nodule dips into the tissues beneath the skin and at about the eighth month of fetal life undergoes a central necrosis thus establishing the lumina of the milk duct. At birth the nipple is not usually present but the mouths of the primitive ducts are seen in a dimple or cleft which is extruded to form an elementary nipple during the first month of life.

The nipple and primary ducts remain in this phase until under hormonal stimulation the process of sexual differentiation is accomplished in adolescence. Even then the growth of the breast is largely a secondary sexual characteristic for although the ducts develop proportionately the bulk of the breast is made up of fat and fibrous tissue. The formation of acini and the conversion of the breast into a secretory organ await for the most part the hormonal stimulation associated with the processes of reproduction.

**Gross Anatomy.**—The breast of the adult male unaffected by the secondary sexual differentiation remains as a vestigial structure and is of little significance. On the other hand the female breast is a highly differentiated organ and its anatomy is of great importance. Its general appearance and location scarcely need description but its intrinsic structure and its relationship to a joining tissues must be further considered. It lies slung between the deep and superficial fascia and the fibrous septa traversing the gland between these two layers are known as Cooper's ligaments. They not only serve to divide the breast into lobes or compartments but, inasmuch as the superficial layer of fascia is intimately attached to the skin over-

lying the breast, they also localize and guide disease processes in such a fashion that the changes in the skin are often of the greatest significance. Moreover the nervous, vascular and most important of all lymphatic distributions of the breast follow these fascial planes while the specific secretory components of the breast lie enclosed within these compartments. The pectoral fascia is a rather dense connective tissue structure overlying the muscular and bony components of the thoracic walls and contiguous with the similar layer beyond the site of the breast. It serves as a limiting membrane between the breast and the underlying structures but is penetrated by and carries with it various contributory structures to the breast notably the lymphatic apparatus. The drainage from this is for the most part through the nodes in the axilla, although flow to the lymph vessels within the thorax and in fact in all directions is not inconsiderable.

**Microscopic Anatomy.**—Finer observation of the breast shows it to be an alveolar gland made up of 15 or 20 lobes each with its duct enlarging into a lacuna as it approaches the nipple and opening at the apex of these structures by multiple pores. The main ducts in the nipple are lined with a squamous type of epithelium which passes over as one follows through deeper into that of a cylindrical type until when the acini are reached a more cuboidal epithelium is found lying in two layers. These are seated on a *membrana propria* and surrounded by connective tissue related more closely to the epithelial structures than to the supporting fibrous framework.

**Anatomical Variations.**—The anatomical variations are those of deficiency or excess and may include the breast or nipple either alone or combined.

**Complete absence of the breast and nipple** is a rare condition frequently associated with an agenesis of the pectoral muscles. In those unusual persons with a developmental lack of sweat glands, the breasts may likewise be absent. Rarely, the breast may be present without any suggestion of a nipple although a retarded or imperfect development of the latter is fairly common. Such congenital variations in the size and form of the nipple are the flat bivalvular or split and the buried nipple. These are of significance only as they interfere with nursing or lead to confusion in the diagnosis of acquired disease.

**Accessory Breast.**—The accessory, fully developed breast with nipple which is capable of lactation is well known and forms a



chapter in all collections of medical curiosities. This anomaly may be multiple with a series of breasts as in the sow but is more customarily a bilateral accessory breast just above or below the normal one. Whenever it is present with but the rarest exception it is located along the embryonic milk ridge. Much more frequent indeed a common anomaly if looked for is the accessory nipple unaccompanied by any discernible breast tissue and many times scarcely more than a small thickened and pigmented area in the skin. These variations are of no significance other than psychic but this in itself may justify removal. There is no evidence that the supernumerary breast is any more likely to be the site of neoplasm than is the usual form.

The *aberrant breast* is a somewhat different matter. It occurs in the axilla usually directly contiguous to the upper and outer margin of the normal breast and on cursory examination may be readily mistaken for a lipoma. It is more commonly discovered at lactation when it responds as does the normally placed organ. It seems although this is a matter of clinical impression rather than of statistical evidence particularly liable to carcinoma and on the slightest suspicion should be removed.

Another type of aberrant mammary tissue which closely associates the breast with the sweat gland is the *cutaneous gland of the axilla*. This apparently a differentiation from the apocrine glands present there responds by proliferation and secretion at the onset of lactation continues in this state for about a week and in another week is again quiescent.

**Functional Variations**—The functional variations of the breast may be divided roughly into three categories the boundaries of which are not sharply defined and which at times may occur more or less simultaneously. These are the growth of the breast accompanying the development of secondary sexual characteristics the changes involved in the menstrual cycle and the mobilization for lactation. All three of these activities are determined by hormonal stimulation or perhaps by a shift in hormonal balance the pituitary and the ovarian or testicular hormones being chiefly concerned.

The structures in the breast which are

played on by these hormones are the epithelium of the ducts and acini and no less important, the periductal and periacinar connective tissue.

The differentiation of the female breast is accomplished as far as mass is concerned largely by an increase of fat and supporting fibrous tissue for which internal secretions of the anterior pituitary are responsible. To this must be added however an increase in the branching and length of the ducts and a striking proliferation in the periductal connective tissue so that the breast becomes skeletonized as it were for its future function of lactation. This phase of the growth

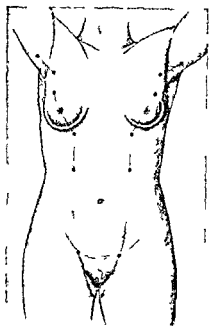


Fig. 453.—The "milk line" along which accessory breasts and nipples occur. (Merkel Topographical Anatomy.)

is probably induced by the estrogenic substance.

With the establishment of menstruation a rhythmic change occurs in the breast as is the case with the endometrium and probably as a result of the same hormones. The precise details of this are not well known but in many instances there is subjective discomfort a sense of fullness at or just antedating menstruation and in some instances a slight discharge from the nipple. Rarely this may be bloody the so-called *menstruous menstruation* although it is far safer to assume that such a discharge arises from a ductal papilloma. Histologically the acti-

vation is marked by a proliferation of ductal epithelium and of the periductal connective tissue and with the passing of the estrus these return to a resting phase. When this periodic stimulation comes to an end with the menopause the specific structures of the breast undergo a fairly complete involution so that nothing remains but the dilated ducts, a minimum of periductal tissue and an atrophic supporting structure making up the senile breast.

When the ovum is fertilized and becomes implanted the breast continues on into a development preparatory for lactation. The ducts branch and extend more deeply and at their terminations acini develop while the periductal and pericinar connective tissues undergo marked hyperplasia. The breast increases in size as a result of these activities, becomes more vascular and with the termination of the pregnancy under the influence of an anterior pituitary hormone (prolactin) starts producing milk. With the cessation of nursing the gland undergoes involution to a resting stage and with the recurrence of the estrus cycle again takes up its menstrual rhythm.

**Functional Aberrations**—Directly after birth the breast of the infant shows rapid growth with extrusion of the nipple and it is not at all uncommon, probably under the influence of the prolactin of the mother, for the breast in a few days to secrete a small amount of so-called 'witches' milk. This turgidity of the breast and discharge are sometimes mistaken for infection but this is rarely the case and with the passage of a few days the phenomenon subsides.

Likewise at the time of puberty fullness of the breast and the presence of small amounts of milk are occasionally noted. This condition may be observed in the male or female. This is again probably the result of a disturbance of the balance between estrogenic substance and prolactin.

In the male the enlargement of the breast may persist or even increase a condition called *gynecomastia*. It is discovered at all ages but not rarely in routine examinations of male students of the college age. It is usually bilateral but to some degree may be unilateral. There is frequently discomfort or even sticking, painful sensations. On inspection a miniature breast and nipple are

apparent and a small elastic disk of breast tissue may be felt. Microscopic examination shows ductal but not acinar proliferation and increase of periductal fibrous tissue. Occasionally there are small cysts and the whole appearance resembles in a minor degree cystic disease of the breast of the female. At other times the appearance is that of the normal breast of the female child. Gynecomastia is occasionally associated with anomalies of the genital apparatus or endocrine disorders. There is no correlation of this condition with malignant disease.

In the female a continued stimulation by estrogenic substance of the growth of the breasts leads at times to 'virginal hypertrophy' which in extreme instances forms one of the curiosities of growth. The breasts may be truly enormous, so much so as to be not only a source of embarrassment to the patient but an actual physical handicap. This aberration usually involves both breasts and in fact unilateral hypertrophy should lead one to suspect a massive lipoma or fibroadenoma of the breast.

Microscopic examination shows a true hypertrophy of the breast with the periductal fibrous hyperplasia predominating and the ducts themselves being relatively inconspicuous. There is a high incidence of fibroadenoma in virginal hypertrophy and growth is particularly rapid at puberty and during pregnancy. As has been pointed out recently, there is considerable probability that gynecomastia, virginal hypertrophy and fibroadenoma are the result of excessive hormonal stimulation of the same type, the estrogenic substance that is concerned with the normal growth and differentiation of the breast.

**Disturbances of Circulation and Involution**—Very rarely does spontaneous *hemorrhage into the breast* occur and then in conjunction with the usually hyperemic breast of menstruation or of lactation. Much more common is bleeding from a cyst already present caused by a papilloma or trauma. A localized injury may lead to hemorrhage into the breast and fat necrosis. The immediate result is frequently overlooked and the patient complains of a lump in the breast. It is exceedingly difficult if not impossible to distinguish this from carcinoma short of a biopsy and this should be done.

While massive necrosis or gangrene of the breast has occurred as a result of a general mixed streptococcal infection unfortunately the most common cause is that of hypodermoclysis of a physiologic or hypertonic saline solution directly into the breast. Under these circumstances the fibrous ligaments of the organ serve to confine the fluid until the pressure is sufficient to obliterate the arterial supply and a massive necrosis occurs.

Disturbance of the innervation is confined to neuralgia of the breast, more commonly called mastodynia. While this may be a true disease of the nerves supplying sensation to the breast or even an hysterical manifestation it is always much safer to avoid such diagnoses and search for an organic lesion. This will usually prove to be a cystic disease of the breast in which pain and discomfort are frequent symptoms.

#### Inflammatory Diseases of the Breast —

A common and painful affection of the nipple is the fissure which arises as a result of nursing. This is not only important from the discomfort involved and the interference with suckling but frequently acts as a portal of entry for pyogenic organisms thus leading to abscess of the breast. The best prevention is cleanliness before and during lactation and this is best achieved by washing with sterile water and painting with a dilute compound tincture of benzoin. The use of strong antiseptics only leads to further damage and when the discomfort is great an artificial nipple may be used or in the extreme instance nursing abandoned and the breast pump substituted for it. An ulceration of the nipple should suggest at once either carcinoma or the primary sore of syphilis.

The areola is an area in which the skin is thin as parchment unattached to the underlying superficial fascia and contains the large sebaceous glands of Montgomery.

The areola is subject as is the skin of the nipple to what is commonly called eczema. This is not in any instance a sufficient diagnosis and all care must be exercised in arriving at the true etiology. Such is peculiarly the case in this region because eczema is not an uncommon manifestation of an underlying ductal carcinoma, the so-called Piget's disease (see section on Piget's Disease). In other instances the causative

agent quite unsuspected and not obvious is the itch mite of scabies and the pruritus and scratching may lead to infection resulting in an abscess lying between the skin of the areola and the superficial fascia. Such a localized infection may also arise from infection of the glands of Montgomery. Lastly similar excoriation and infection may lead to an impetiginous eczema which may spread over the skin of the entire breast. Another and very common cutaneous lesion associated with the breast is intertrigo which occurs in the fold beneath the pendulous breast particularly in a patient who is not scrupulously clean.

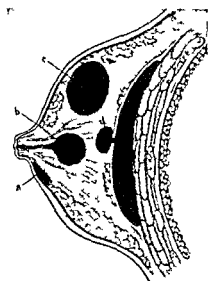


Fig. 44.—The location of breast abscesses: a Sub-areolar abscess; b retro-areolar abscess; c intramammary abscess; d inter-areolar abscess (After Klose.)

It is not at all uncommon in the first few days of onset of lactation or at other times when the breast is not adequately emptied for caking to occur. A segment or even a major portion of the breast becomes turned painful and tender and on palpation feels dense and warm as compared with the surrounding tissues. There may be some fever and leukocytosis and the possibility of a beginning abscess is at once suggested. The mechanism is that of a stasis and curdling of the milk within the lobules of the breast and a mild inflammatory reaction. With gentle application of the breast pump support of the breast with a firm binder and icebags for comfort the condition usually recedes.

and there is no impairment of the lactational function of the breast

This condition is to be differentiated from abscess of the breast, which usually starts somewhat later, 1 or 2 toward the second month of nursing and is the result of a pyogenic infection most frequently staphylococcal through the lymphatics from a fissured or excoriated nipple. At times this infection is imposed on a stagnation of milk and the differential diagnosis is difficult. Pyogenic infection is indicated by a marked accentuation of the milder symptoms. The breast or a sector of it is tense, excruciatingly tender and painful and quite hard to the touch until such time as suppuration leads to fluctuation, a late phenomenon. The systemic reaction is much sharper, often starting with a chill and with a rise in temperature to 104° or 105° F. Leukocytosis is marked with the segmented forms predominant. The final differential diagnosis must wait on localization of the process with redness and edema of the overlying skin and even fluctuation. In some respects the process resembles a carbuncle of the neck in that the infection is first confined within the lobular fibrous compartments of the breast from which it may reach the skin or if more deeply seated may penetrate into other compartments and thus involve a major portion of the breast before fluctuation is detectable. Therefore fluctuation must be diligently sought for and drainage established at once when it can be found.

For this purpose it is important to make radial incisions outside the areolar region in order to avoid dividing the larger ducts and possibly causing a milk fistula. It is equally important to drain the region thoroughly with all liquefied areas opened up in such a fashion as to obtain dependent drainage. A through and through rubber-covered drain from outside the areola traversing the abscess radially and emerging at the outer margin of the breast accomplishes the most with the least damage. It is necessary to stop nursing entirely even with the unaffected breast for the act of sucking would stimulate the flow of milk in the diseased breast also. The breast pump should be gently used to remove the excess milk. The breasts should be firmly supported and an icebag used.

"Chronic Cystic Mastitis"—It is customary to consider under the chronic inflammatory diseases of the breast a condition which although clinically and pathologically definite as far as its etiology and its relation to malignant disease are concerned has been and still is the subject of controversy. It was first recognized as an entity by Sir Astley Cooper but the notable studies of Reclus and Schimmelbusch focused attention on the condition. Unfortunately almost without exception each investigator devised a new name which serves rather to confuse than to clarify the situation. Probably the term 'cystic disease of the breast' is sufficiently inclusive and non-committal to represent the state of knowledge concerning the condition.

The more recent studies concerning the influence of the hormones on the growth and function of the breast have been considered briefly. That they have some bearing on the etiology of this disease can no longer be questioned but the details of this action are open to further elucidation. Quite aside from such hormonal interpretation it is known that the breast concomitantly with the estrus cycle undergoes stimulation and regression. This is shown histologically by hyperplasia of the periductal fibrous elements and the epithelium of the ducts with budling and branching which if fertilization and implantation of the ovum occur continues during pregnancy until lactation supervenes at birth. With the completion of menstruation the breast like the endometrium undergoes involution and returns to a resting stage. It requires no considerable imagination to conceive of this process as becoming exaggerated and unbalanced as happens in the case of the endometrium leading to greater than normal activity of either the fibrous or the epithelial hyperplasia or both and likewise incomplete involution from either the normal or the exaggerated response. In any case there may well result a fibrous overgrowth or an epithelial overgrowth or a combination of both. The generalized overgrowth of the periductal fibrous tissue has been discussed under vaginal hypertrophy and the localized overgrowth resembles at least that seen in fibroadenoma. Likewise the epithelial hyperplasia within the membrane propria surrounding the ducts may be general

ized or localized and may result in adenomatous collections of cells increase in ducts and acini and the formation of cysts of varying size. When the disturbance of the normal process includes as it usually does both the fibrous and epithelial elements the picture becomes extremely variegated and it is not at all surprising that confusion of description and interpretation results.

In the recognition of this disease the subjective findings are much more prominent than they are in malignant disease of the breast. There is commonly a sticking pain

but on examination one usually finds other evidences of disease. Frequently there are other smaller nodules but they may be grouped together in one area so that there seems to be a mass surrounded by induration closely simulating carcinoma. Fortunately palpation of the entire breast more often reveals multiple nodules of varying size or gives a shotty feel or beneath the areola there is the sensation of palpating a clump of worms. Again the breast can be picked up as a thickened and resilient disk, the so-called saucer breast. Examination of

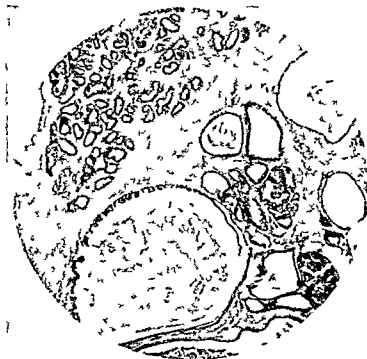


Fig. 155.—Hyperplasia, hypermatured secretions and cyst formation occurring in the duct epithelium of the breast in cystic disease. (After Cheate and Cutler.)

often referred to the shoulder or to the inside of the upper arm. It is obviously a referred type of pain and is rarely severe. Very characteristic is its increase at about the time of menstruation; the breasts at the same time becoming tender. Visual inspection rarely indicates any abnormality, although a single large cyst may at times cause obvious deformity.

Palpation usually reveals a greater degree of tenderness than accompanies other tumors of the breast. There is no intimate attachment to the skin and the breast itself is not fixed to the underlying tissues. The patient frequently complains of a single lump

the opposite breast also reveals definite disease in the majority of instances.

The differential diagnosis is that from benign and most important of all malignant tumors. In the former case there is much less likelihood of multiplicity of lesions but the clinical distinction of a fibroadenoma from a single cyst is difficult. Transillumination should in theory pass through a cyst but not a solid tumor even as one would expect less resistance or even fluctuation in the cyst. In practice these distinctions are of little assistance except in tumors the size of a bird's egg or larger. The same is true also of examination by the soft roentgen ray.

At times the simple, obviously benign tumor may be aspirated with a fine needle in order to establish a preoperative diagnosis but inasmuch as such a tumor should be removed irrespective of the findings this maneuver is of but little practical value.

Much more important is the distinction of this disease from neoplasm particularly carcinoma. Involvement of the skin retraction of the nipple fixation of the breast and other similar signs are indicative of relatively advanced disease. Today more patients ask for advice when these characteristic signs are not present even in cancer and consequently while the differential diagnosis becomes more difficult the responsibility of the surgeon at the same time becomes greatest. When there is a single dense nodule in the breast irrespective of what may be present otherwise the diagnosis of non malignant disease can not be made short of an exploration of the lesion. Where no nodule is present and both breasts are involved to some degree in uniform disease the diagnosis of benign disease may be made with a considerable degree of safety.

The course of chronic cystic mastitis is a slowly progressive one with little disability aside from that of a subjective nature. With the climacteric and the onset of senile involution the process subsides or remains quiescent. While the incidence of cancer in the breast so involved is somewhat higher than that in the corresponding age groups this difference is not sufficient to justify ablation on this basis alone. However it is of the greatest importance that early carcinoma in the breast involved in a 'chronic cystic mastitis' is difficult to discover and still more difficult to rule out. Therefore it is necessary to watch such breasts with greatest care and at the slightest suspicion to proceed at once in establishing the diagnosis by exploration.

Were this possibility of confusion not present in many instances the surgeon would adopt an expectant attitude. As the situation frequently occurs he will feel called on to carry out an operative procedure. In certain instances particularly in middle aged patients a conservative mastectomy is indicated but even this causes a mutilation to be avoided if possible. Frequently the local resection of a quadrant of

the breast which is most intensively diseased will settle the question of cancer in that area and where there is a discrete movable nodule the removal of this will determine its character at once. Certain it is however that the surgeon who carries out any of these procedures with the primary aim of ruling out cancer must be a competent gross pathologist who can diagnose the lesion at first hand with a reasonable degree of certainty. Likewise he should be sufficiently familiar with the microscopic appearance in the frozen section which should always be available so that he in consultation with the pathologist may arrive at once at a decision as to whether or not a radical attack for cancer is necessitated.

S C HARVEY

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#### TUMORS OF THE BREAST

The mammae are modified cutaneous glands. In the male they atrophy after birth. In the female they are "dormant" until puberty when they hypertrophy but attain full functional development only at the end of pregnancy to fulfill their prime function—lactation. Regress on occurs after weaning but never to the state existing prior to pregnancy. Definite cycles of proliferation and regress on take place with each menstrual cycle, owing to hormonal influences especially from the pituitary and ovaries. Atrophy ensues after the menopause.

In a full females the breast tissue proper is in the form of a disc surrounded by fibroadipose tissue. Its most superficial portions are beneath the areolae pigmented circular areas in the center of which is the nipple. Fifteen to twenty lactiferous ducts terminate in the nipple each with its own orifice. Each lactiferous duct corresponds to a lobule of breast tissue; these are arranged radially about the nipple. The lactiferous

ducts are continuous with smaller ducts which subdivide repeatedly forming fine tubules. The latter end finally in sacs or acini. In lactation the cells of the acini undergo transformation into milk-secreting cells. The connective tissue immediately surrounding the smaller canaliculi and acini is loose and relatively cellular. It responds to hormonal influences as does the breast epithelium and undergoes changes concomitantly with the latter. The size and contour of the breast and the quantity of breast tissue proper vary widely and differently and vary duals corresponding to the general constitutional type.

**Examination of the Patient**—When the female breast is examined for neoplasm a definite routine should be followed. The physician should never be satisfied with rapid cursory haphazard palpation. Complete exposure of both breasts is necessary. Each breast is first inspected while the patient is sitting upright or standing. Attention is focused upon the general contour and appearance of the skin and nipple. Search is made for localized bulges or depressions. The relative size of each breast is noted. Palpation is carried out by gentle grasping of different portions. The patient is then requested to lie down upon her back and inspection again carried out. The arm is fully abducted so that it is parallel to the side of the head with the forearm horizontal over the top of the head. Palpation is carried out with the flattened hand pressing the breast against the ribs and moving it backward and forward. Palpation in a similar manner is carried out upon the terminal portions of the pectoralis major muscle which form the anterior axillary fold. Palpation of the floor of the axilla is carried out by pressure of the fingers directed against the mesial wall of the axilla (ribs) and then forward onto the under surface of the terminal portion of the pectoralis major muscle and toward the apex of the axilla. Finally the hand is cupped about the breast with moderate compression in order to ascertain whether or not any discharges can be expressed from the nipple.

The female breast is a common site of neoplasms both benign and malignant. While the breast includes the skin and its appendages and fatty and fibrous tissue and therefore may exhibit tumors of these tissues only those tumors peculiar to the mammary gland proper will be considered here. These may be classified as follows:

#### Benign

- I Fibroadenoma
- II Pericanalicular fibroadenoma
- III Intracanalicular fibroadenoma
- IV Adenoma
- V Intracanalicular papilloma
- VI Cystosarcoma phyllodes

#### Malignant

- I Carcinoma
- II Paget's carcinoma
- III Sarcoma

### BENIGN TUMORS OF THE BREAST

**Fibroadenoma, Pericanalicular Fibroadenoma and Intracanalicular Fibroadenoma**—Clinically these benign tumors may be considered together. They are ob-

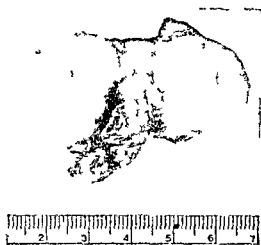


Fig. 450.—A benign tumor of the breast in this case an intracanalicular fibroadenoma. The granular appearance of the cut surfaces is due to small intracanalicular papillary projections. Note the color of the tumor in contrast to the normal breast tissue between divided halves.

served in females most frequently between the ages of twenty and forty-five. The tumor is usually not painful or tender on palpation although pain and tenderness may on occasion be present and often is referred to the shoulder axilla or arm especially in the immediate premenstrual period. The common sites are in the breast beyond the areolae. The tumor is usually on the superficial aspect of the disc of breast tissue and produces a circumcribed bulge but it may also be deeply embedded. On palpation it is quite firm, may exhibit a stiff elasticity, appears to be well encapsulated and seems quite mobile on the surrounding tissue especially when it is superficial. When a finger is pressed downward upon the tumor it

readily moves in one direction or the other. When grasped between the thumb and index finger it may readily slip away from between these digits. If the growth is deeply embedded in the breast, its motility is often quite limited and in some instances affords the impression of an infiltrating process. These tumors are usually single but may be

firm whitish rounded or oval masses sometimes with rounded bulges on one or several aspects (Fig. 45C). Because of their color and density they contrast rather sharply with the surrounding grayish softer breast tissue. They are easily enucleated from the latter. The fresh surfaces of the intracanalicular fibroadenoma exhibit small



Fig. 457—Histologic appearance of various benign breast tumors  $\times 50$ . A Fibroadenoma. Ducts and stroma have proliferated, cystic dilatation of the ducts. Proliferation of stroma. Canals show little cystic dilatation. B Pericanalicular fibroadenoma. Relatively greater proliferation of stroma. Canals show little cystic dilatation. C Intracanalicular fibroadenoma. Characteristic configurations of intracanalicular processes. D True adenoma. Proliferation of ducts and acini with no proliferation of stroma. Large lumen in center of section.

multiple in one or both breasts, the latter condition however is not common. When first seen, the growth varies from 1 to 3 cm in diameter but on rare occasions may be considerably larger. Growth is slow and upon attaining 2 to 3 cm in diameter the tumor may appear to remain stationary for varying periods. Patients may be under the impression that they vary in size.

**Pathology**—Macroscopically they are

raised nodules due to the intracanalicular processes.

The histologic characteristics are as follows (Fig. 457).

**A FIBROADENOMAS**—Both the periductal connective tissue and the duct epithelium have proliferated. The ducts appear numerous slightly to moderately dilated and more or less uniformly distributed in the loose stroma.



**B PERICANALICULAR FIBROADENOMA.**—The periductal and periacinous connective tissue appears to have proliferated more extensively than the epithelial elements. Individual canaliculi or small groups of these are surrounded by relatively wide zones of stroma.

**C. INTRACANALICULAR FIBROADENOMA**—There has been relatively greater proliferation of connective tissue than of epithelial structures, and the former has pushed into the canaliculi, forming coarse indentations leading to dilatation of the canaliculi and almost complete obliteration of their lumina. Characteristic configurations are produced.

Some neoplasms may exhibit, in different areas, combinations of two or even all three of these histologic characteristics.

**Treatment**—The final diagnosis of any breast tumor cannot be made without histologic study. Therefore, if this is desired, excision (which in these growths is just as easily performed as biopsy) is indicated. Indeed, with the extensive anticancer propaganda among the laity in the past years, most patients readily accede to removal of a breast tumor when this is a minor procedure and will afford final confirmation of benignity. On the other hand, in the presence of all the clinical signs that have been enumerated, it can hardly be stated that excision of these tumors is mandatory. Transformation of them into carcinoma or sarcoma is so rare, if it ever does occur, that excision cannot be justified on the basis of ablation of a precancerous lesion. Another reason for their removal is their progressive increase in size. Neoplasms that are tender or the cause of spontaneous pain should be removed. When the neoplasm is resected, recurrences usually do not occur if excision has been complete. However, similar growths may appear later in the same breast near the site of the original growth or in the opposite breast.

**True Adenoma.**—This is a rare tumor. It is composed of numerous, closely applied ducts, canaliculi and acini, with relatively little stroma. These growths vary in size and may be quite firm or soft and fleshy. Some of the recorded instances of true adenoma may in reality represent localized areas of hypertrophy rather than true neoplasms, in that they were observed during pregnancy

and histologically resemble normal breast tissue evolving toward the stage of lactation (Fig. 457, D). The nature of the tumor is appreciated only after excision and microscopic examination.

**Intraductal Papilloma.**—Two types of intraductal papilloma occur—the single lesion and multiple growths. The solitary papilloma usually develops in or near the dilated (ampulla) portion of the terminal segment of the lactiferous duct. It consists of a single basal stalk of attachment from which numerous villous processes arise, the whole forming a rather complex structure



Fig. 458.—Gross appearance of large intraductal papilloma in terminal portion of lactiferous duct. The nipple is on the opposite side of the specimen just over the depicted lesion.

(Figs 458, 459). These growths are covered with low to tall columnar epithelium. When the lesions are multiple they may arise from the smaller as well as the larger ducts and cause dilatation of them in the regions of their growth. A striking situation is the occurrence of multiple lesions confined to one large duct and its tributaries, whereas ducts of adjacent lobes are free from the lesions. Where the papillomas are multiple and situated close to one another, their distal portions may fuse, with formation of a complex intraductal lesion with multiple stalks of attachment (multiradicular growths).

**Signs and Symptoms**—Intraductal papil-

lomas are observed most frequently in women between thirty five and fifty five years of age. The characteristic sign is a spontaneous hemorrhagic discharge from the nipple. When the breast is compressed a drop of the discharge forms on the nipple and resembles the drop of blood resulting from the prick of a sharp instrument on the finger or lobule of the ear as obtained for blood counts (Fig. 460). Less frequently the discharge is essentially serous with traces of blood or it may not be hemorrhagic at all. The papilloma may be palpable as a rounded somewhat elastic nodule usually beneath

are benign but there is good evidence that they may undergo malignant degeneration. No information is available to indicate how long they may remain benign before undergoing malignant changes although they have been observed to remain benign for prolonged periods. Spontaneous disappearance of the growths has also been reported but this is of such rarity that it should not be considered in connection with treatment.

**Treatment**—When the diagnosis is made excision is indicated because of their possible precancerous nature. Single papillomas are excised locally with surrounding tissue. When



FIG. 460.—Intraductal papilloma of the breast.  $\times 20$ .

the nipple or areola. Multiple lesions may be palpated as small nodules in these areas and also farther out in the breast away from the areola. In unusual instances they form masses larger than 1 cm. in diameter. On the other hand the tumors may not be palpable at all because of small size and yet the hemorrhagic discharge from the nipple is regularly present. Intraductal papilloma is in most instances confined to one breast but rarely may be present in both breasts. The single lesion is not painful or tender to palpation; some discomfort may be associated with multiple papillomas.

It is generally stated that these lesions

they are multiple excision should be wide enough to encompass all of the lesions. Recurrences may develop indicating incomplete removal of the original growths or development of new lesions in other ducts.

**'Cystosarcoma Phylloides'**—Although the term cystosarcoma phylloides suggests a malignant neoplasm these growths are benign. They are not very common and are usually observed in women between forty five and fifty five years of age. They are not uncommonly observed in younger subjects. They are characterized by the formation of a very large mass that greatly distorts the breast. On palpation the tumor is

a precancerous condition although certain forms in which considerable intraductal proliferation of cells (adenosis) is present may prove to be evidence of the activity of carcinogenic factors as yet unidentified

Over the years considerable experimental work has been carried out in breast cancer



Fig 401—Section through the breast of forty-two year old woman showing numerous scattered small cysts and a recently biopsied carcinoma (T) Two years previously a large cyst in region C was aspirated of yellow cloudy fluid No gross evidence of the cyst is present in the specimen

in mice There are strains in which the females have a high incidence of breast cancer and strains of low or no incidence of this tumor Oophorectomy in early life prevents normal maturation of the breast and in such rudimentary glands carcinoma does not develop even though the animals are

of the high incidence strain Large doses of estrogens have hastened the development of breast cancer in susceptible females and even led to its development in males of the high incidence strain A factor in the milk of high incidence strain has recently been discovered by Bittner which plays an important role in the development of breast cancer in mice If the newborn mice of a high incidence strain female are immediately removed from the mother and suckled by a low incidence strain female the incidence of breast cancer in the females will be appreciably reduced If the young of low incidence strain are suckled by a lactating female of high incidence strain the number of carcinomas of the breast in the females will be appreciably increased The milk factor is not the only influence However since an hereditary predisposition to breast cancer also obtains

**Pathology**—Carcinoma may arise in any portion of the breast but seems to be more common in the upper outer quadrant The growth is highly infiltrative and spreads by direct extension within the ducts infiltration of the surrounding fatty tissue and permeation of the lymphatics Macroscopically the tumor tissue is dull gray and often semicartilaginous in appearance and consistency The cut surfaces are smooth and mottled gray and yellow Small cystic spaces with brownish or hemorrhagic fluid may be present or they may contain sebaceous like material Infiltration of the lymphatics and areolar tissues gives rise to an inflammatory reaction which results in contraction of the tissues toward the growth The terms scirrhous and medullary as applied to carcinomas of the breast have come down from the older literature and are gross descriptions signifying the firm and more fleshy varieties of the neoplasms respectively

There is a wide variety of histologic types which will not be discussed in detail here They correspond roughly to the gross scirrhous or medullary forms (Fig 402) in that the former is characterized by infiltration of tubules and cords of malignant cells surrounded by a dense fibrous tissue reaction and the latter by large irregular masses of epithelial cells with relatively little stroma and less fibrous tissue proliferation

Metastases from carcinoma of the breast

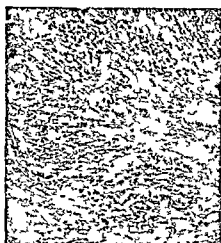
may occur early in the course of development or may not take place until the process has become well advanced locally. In young subjects metastases occur earlier and are more widespread than in older patients. They are both lymphogenous and hemogenous. The first metastases are lymphogenous and are usually to the axillary lymph nodes, the infraclavicular and supraclavicular nodes are subsequently involved. However, where the process arises deeply within the breast and near the pectoral muscle spread into the lymphatics of the chest wall and via these to the subpleural spaces, mediastinum and even into the abdominal subperitoneal space and abdominal viscera may occur. The latter types of metastases

lymphogenous spread rather than by hemogenous dissemination which is the usual pathway for this type of metastases.

**Diagnosis**—The typical well established carcinoma of the breast presents such characteristic features that the clinical findings suffice for diagnosis (Fig. 463) yet final confirmation by histologic examination should always be made. Aspiration biopsy by means of the proper sized needle or special devices has gained favor in some quarters and in expert hands appears to be satisfactory especially when the findings are positive. In the face of suggestive clinical evidence for carcinoma negative aspiration biopsies should not be accepted as final. A good practice is to prepare the patient for radical op-



A



B

Fig. 462—A Histologic appearance of "medullary" carcinoma of the breast showing large masses of cells. B Histologic appearance of scirrhous carcinoma of the breast showing scattered cords and tubules of malignant cells in dense stroma.

may develop extensively before there is appreciable invasion of the axillary lymph nodes. From the mediastinal lymphatics spread may occur into the thoracic duct and via this channel into the left jugular and subclavian veins. On the other hand permeation into the blood vascular system also takes place at the primary site and by this route metastases are carried into the lungs, liver, brain and elsewhere. Metastases from carcinoma of the breast are frequently present in the skeleton and they may extensively involve the osseous system while visceral metastases are few or not present at all. Diffuse skeletal involvement of the regions adjacent to the affected breast has sometimes been attributed to direct massive

invasion. In performing biopsy by incision into the suspected mass obtain an adequate block of tissue or preferably excise the entire mass for frozen section and then close the wound. New instruments, new gloves and possibly new drape and gowns are obtained while the histologic study is in progress. If the report is positive appropriate treatment then follows immediately.

As stated previously when the clinical signs of breast cancer are obvious the outlook for the patient is guarded. The prognosis is much brighter following proper treatment when the clinical diagnosis is of a small lesion is questionable and reliance upon biopsy findings is necessary for final diagnosis.

The clinical signs and symptoms include the following:

**1 Lump in the Breast** A lump in the breast is by far the most important finding in cancer of the breast. Its discovery is particularly important for the early diagnosis. The history given by the patient that the lump was accidentally discovered is a characteristic feature of the clinical aspects of breast cancer. In the early stages the malignant growth is not painful or tender. The tumor is quite firm and because of its infiltrative growth the outlines are indefinite. There is no encapsulation and the breast

**3 Retraction of the Nipple** Where the neoplasm is situated beneath the nipple or near it beneath the areola, retraction of the nipple occurs as a result of infiltration of the subcutaneous lymphatics and lactiferous ducts by the growth. Retraction of the nipple may be sufficiently pronounced to afford the appearance of elevation of the most pendulous portions of the breast. This elevation is more easily appreciated when comparison of the contour of the affected breast is made with the unaffected opposite breast.

**4 Orange Peel or Pigskin Appearance of the Overlying Skin** When the subcutane-

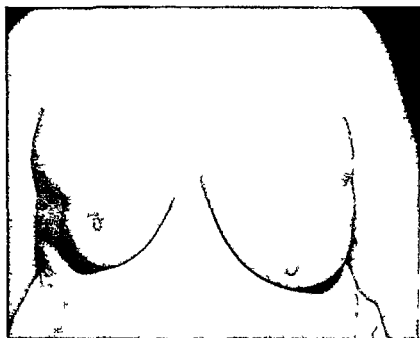


FIG. 463.—Sixty-five year old patient with classical signs of well advanced carcinoma of the right breast. The involved breast is elevated, the nipple is retracted and there are two well marked areas of dimpling of the skin above and lateral to the areola.

tissue immediately surrounding it moves with the tumor in contrast to the mobility of certain benign tumors in the surrounding tissue.

**2 Dimpling of the Overlying Skin** When the growth is present in the superficial aspects of the breast and permeates the lymphatics which communicate with those immediately beneath the skin, the latter is drawn downward toward the growth, producing a characteristic depression or dimpling. This may not be readily apparent on simple inspection, but if an attempt is made to move the lump the skin will be drawn with it and the dimpling thus accentuated.

ous lymphatics are occluded by tumor cells with blockage of lymph flow in the area, the skin between the pores becomes puffy, accentuating the size of each pore. This gives rise to the appearance of orange peel or pigskin.

**5 Elevation of the Breast** The involved breast may appear retracted onto the chest wall and the nipple distinctly elevated as compared to the opposite breast. This condition is encountered where the carcinoma has invaded most of the disc of breast tissue and has become attached to the pectoral fascia, producing general contraction of the surrounding connective tissue.

**6 Discharge from the Nipple** This is in constant and has little diagnostic significance, because certain forms of cystic disease, infectious lesions and intraductal papillomas may produce discharges of various types from the nipples. Hemorrhagic discharges may, however, be present in cancer.

**7 Palpable Lymphadenopathy in the Corresponding Axilla.** The presence of firm nodules in the axilla indicates metastases to the axillary lymphatic nodes. Absence of these nodules does not preclude metastases since the adipose tissue may mask their presence.

indeed an acute carcinomatous cellulitis. Prognosis is extremely unfavorable.

**8 Ulcerating Cancer of the Breast.** While ulceration through the skin eventually occurs in many neglected cases late in the evolution of the disease, small lesions arising in the superficial portions of the breast may ulcerate relatively early, especially in elderly patients while the breast itself is not yet extensively involved. Prognosis can be estimated on the basis of axillary metastases in instances of early ulceration.

**4 Cancer of the Breast in Pregnancy and Lactation.** This situation has a grave prognosis. It is assumed that the physiologic factors inducing lactation operate to increase the rate of growth of the carcinoma. On the other hand the patients are usually young and rapid growth of carcinoma is the rule in this group. Furthermore, because of pregnancy and lactation there



Fig. 461—Cancer en cuirasse with area of imminent ulceration above and mesial to the areola. The involved breast is converted into a firm, flattened disc contracted against the chest wall. This represents an advanced stage of the disease.

#### *Special Clinical Forms of Carcinoma of the Breast*

**1 "Cancer en cuirasse" (Fig. 461).** Extensive local infiltration with fibrosis and lymphedema of the tissues results in dense firmness of the breast which is retracted against the chest wall. The infiltration may extend beyond the actual limits of the breast onto the chest wall surrounding it. The condition has been likened to a breast plate hence the name. It represents an advanced stage of the disease.

**2 Inflammatory Cancer.** In some patients usually young subjects the process appears to grow rapidly and permeates the cutaneous lymphatics with spread over the skin of the breast, the skin of the axilla and the chest wall at some distance from the breast. The involved areas are erythematous and may be slightly raised. Reddened plaques may be present in the skin at some distance from the breast. The whole process resembles an acute cellulitis hence the name. It is

is local congestion of blood vessels and lymphatics, and this in itself would favor metastases. Prolonged survival can hardly be envisaged in these patients, although in rare instances "cures" have been reported.

**3 Bilateral Carcinoma of the Breast.** Bilateral carcinoma may be present or one breast may be affected and resected with carcinoma developing later in the other. In the latter it usually appears in the subareolar portion and has been regarded as due to lymphatic metastases across the chest wall. However, an independent process developing as a result of strong carcinogenic factors in the patient is an equally plausible explanation. The prognosis depends upon the extent of spread of each lesion. Prolonged survivals have been observed following bilateral radical mastectomy for carcinoma.

**6 Carcinoma in Aberrant Breast Tissue.** Small foci of aberrant breast tissue, in reality independent super-

numerary breasts are not very infrequently present on the borders of the pectoral muscles forming the anterior wall of the axilla or in the subcutaneous tissue of the floor of the axilla. Carcinoma with rather typical signs may on rare occasions develop in these rudimentary glands while the corresponding fully developed normal mammary glands does not include a malignant tumor.

7 **Comedocarcinoma.** This form of breast cancer first recognized by Bloodgood is characterized by relatively slow growth, the formation of a rather lump-like mass with indefinite outlines and relatively late metastases. A serosanguineous discharge from the nipple frequently occurs. The cut surfaces exhibit numerous small plugs of sebaceous-like material. Histologically the rounded masses of malignant epithelial cells exhibit cores of amorphous material which represent degenerated tumor cells and which afford the numerous small sebaceous-like plugs seen macroscopically. In some instances of slowly growing comedocarcinoma whole masses of tumor cells appear to have undergone degeneration into amorphous material. Foreign body giant cells are mobilized to the periphery or invade the masses affording a picture not unlike that seen when a sebaceous cyst ruptures into the surrounding connective tissue. Comedocarcinoma has developed at the termination of pregnancy or during lactation and the prognosis even under these conditions is not very grave especially if metastases have not occurred.

**Treatment.**—The universally accepted treatment for carcinoma of the breast is radical mastectomy, the principle of which is resection en masse of the breast underlying pectoralis major and minor muscles and axillary contents. The fascia over the serratus anterior (medial axillary wall) and over the anterior border of the latissimus dorsi is also resected.

The steps in the operation may be briefly summarized as follows. The patient is given general anesthesia lying flat on the back with the arm abducted 90 degrees.

1 The incision (Halsted) begins over the insertion of the pectoral muscle on the humerus and curves upward and inward over the head of humerus downward on the anterior chest wall mesial to the inner border of the breast then deflecting outward to a point beneath the midportion of the inferior border of the breast. Another incision is begun starting from a point on the first incision above the superior border of the breast and curving outward along the lateral border to meet the termination of the first incision below the breast. The incision on the anterior chest wall is then carried downward to the pectoral fascia. The other portions of the incision are carried well into the subcutaneous fat.

2 The fibers of the pectoralis major arising from the clavicle are separated by the scalpel handle from those arising from the anterior chest wall a digit is hooked beneath the insertion of the latter near the upper end of the humerus and the fibers are divided. The detached portion of the pectoralis major is then drawn downward and medially with division of vessels and nerves to its deep surface. The lateral border of the anterior axillary fascia is then incised over its entire length and elevated. This permits entrance into the axilla.

3 The insertion of the pectoralis minor upon the coracoid process of the scapula is transected and this muscle is also drawn medially and downward with the pectoralis major. The axillary contents en masse are liberated from the walls of the axilla and kept retracted firmly against the detached pectoral muscles. Vessels and nerves coursing downward from the large vessels and nerves in the apex of the axilla are divided.

4 The incision on the anterior chest wall is then carried through the pectoral muscle to the underlying ribs. The fascia over the anterior border of the latissimus dorsi muscle is dissected upward to come away with the axillary contents. The fascia over the mesial wall of the axilla is likewise dissected to come away with axillary contents.

5 The attachments of the pectoral muscles to the ribs are divided and this finally permits removal of the breast, pectoral muscles, axillary contents and adherent fascial strips en masse.

6 Complete hemostasis is important.

7 A stab incision is made in the lower skin flap to permit insertion of a soft rubber drain into the axilla.

8 The line of closure of the wound should not cause a web to be formed on the anterior axillary fold as this would impair motion at the shoulder joint. The cicatrix should eventually lie on the chest wall itself (Fig 465).

Passive motions of the arm are carried out the day after operation and the patient is encouraged to perform active motion as soon as possible.

There is considerable variation in the details of this operation as performed by various surgeons. For example there are many types of incision such as an elliptical one

beginning over the anterior aspect of the shoulder, including the breast and ending over the insertion of the rectus abdominis muscle on the lower anterior chest wall; a circular incision about the breast, with an extension to permit axillary dissection, a long transverse incision to include the breast, etc. There are also various recommendations for undermining the skin to permit approximation in closure or the fashioning of large flaps to accomplish the same purpose. There is the question of how much skin should be removed, some claiming that this should be sufficiently wide that skin grafting is routinely necessary, while others

gross evidence of distant metastases but with local evidence of advanced disease simple or even radical mastectomy is justified for palliative purposes to avoid or remove local ulcerations and ablate the breast tumor. An attempt to select patients for radical mastectomy would, in the author's opinion, result in inadequate treatment in some instances, as experience has shown that not very infrequently survival in comfort is possible far beyond what might have been anticipated. On the other hand radical mastectomy is not justifiable in cases of inflammatory cancer if the incisions cannot encompass the growth or if the progress of



Fig. 465.—Photograph after radical mastectomy showing disposition of areola on chest wall to avoid a web in the anterior axillary fold that would impair motion at the shoulder joint.

maintain that it is necessary to remove only about 4 to 5 cm. of skin beyond the gross limits of the growth (including of course the areola and nipple).

As has been stated, radical mastectomy is recommended in all cases when the diagnosis is finally confirmed by microscopic section, if the incisions may encompass the growth and if there is no gross evidence of distant metastases. Preoperative roentgenographic examination of the chest to demonstrate the absence of pulmonary metastases is recommended as a routine procedure. Radical mastectomy is contraindicated if the latter are present. In patients without

the disease is obviously very rapid in the presence of distant metastases.

The mortality incident to radical mastectomy itself has been progressively reduced in the past few decades; at present it should not exceed 1 per cent among competent surgeons.

**Prognosis.**—Death from carcinoma of the breast results from widespread metastases which lead to exhaustion of the patient or which, by virtue of causing marked general deterioration, predispose to terminal pneumonia or general infections of other types. Skeletal metastases may result in serious pathologic fractures or by extensive re-



placement of hematopoietic marrow may cause a severe and fatal anemia. Intracranial metastases may in themselves be the direct cause of fatality. Thus the prognosis depends upon whether the disease can be eradicated early in its evolution before distant metastases have occurred.

Untreated carcinoma of the breast is not a rapidly fatal process; it appears that the average length of life in the absence of treatment is about forty to forty-eight months from the time the neoplasm is first discovered.

The prognosis in an individual case depends upon the age, type of growth and stage at which operation is performed. In general, approximately 60 to 70 per cent of patients who do not have axillary metastases and do not show infiltration of the skin or invasion of the pectoral fascia will survive at least five years without clinical evidence of disease. If the skin or pectoral fascia is involved and there are no axillary metastases or these are limited, approximately 35 per cent may survive five years; if axillary metastases are extensive but there is no evidence of distant spread, the survival rate falls to about 15 per cent. (In order to gain a definite conception of prognosis, all the axillary nodes should be examined histologically. It is not sufficient to section one or two or the most suspicious nodes.)

Even though the patient survives five years without clinical evidence of active metastases, cure is still not assured, as progression of metastases may become manifested even after this period of arrested growth. Nothing is known of the factors which result in the inhibition of growth of metastases for prolonged periods.

It is not extremely rare to have a patient with metastases, especially where they are confined to the skeleton, survive for prolonged periods, even for several years, under palliative treatment by roentgenotherapy. Large doses of calcium gluconate may also contribute to palliation, especially relief of pain. A grave prognostic sign is local cutaneous recurrences in the area of operation. While these may for a time be the only evidence of recurrences, ultimate death from metastases is the rule, even though the general condition may appear excellent at

the time the recurrent nodules in the operative field are noted.

**Castration in the Treatment of Carcinoma of the Breast**—Since the breasts are stimulated by the internal secretions of the ovaries prior to the menopause, castration has been advocated sporadically for many years as an adjunct in the treatment of carcinoma of the breast, the rationale being that malignant mammary gland cells might also be stimulated by ovarian secretion. Berton was probably the first to advocate surgical excision of the ovaries in women prior to the menopause who had advanced carcinoma of the breast. In recent years, ovarian function has been suppressed by x-radiation in these cases. The reported results have varied and individual inferences have been cited as spectacular examples of the benefits of such treatment. It is, however, generally recognized that the benefit, if indeed they do occur, are temporary and that the patient eventually succumbs from carcinoma. In view of the fact that the question is still a moot one after more than forty years, it would seem to the writer that little is to be expected from castration or a ray sterilization of these patients.

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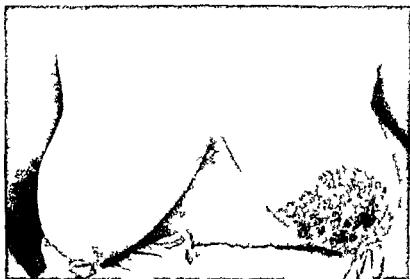
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## II PAGET'S DISEASE OF THE NIPPLE

**Historical**—Sir James Paget in 1854 first called attention to a clinical picture that has today become the subject of great controversy and much confusion. Paget originally described fifteen cases as follows: "Chronic affections of the skin of the nipple and areola

in succeeded by the formation of scirrhous cancer mammary gland'.<sup>1</sup> Although it is now known that the microscopic studies were made of Paget's not all were found to be cases of true Paget's nevertheless he was the first to call attention to the clinical and pathological condition of prime importance. The confusion concerning Paget's disease of the breast is due largely to the fact that Paget's careful descriptive clinical observations were unaccompanied by microscopic study and descriptions. The fact that the surgeon, the dermatologist and the gynecologist all have different conceptions of the disease and McFarlan<sup>2</sup> state: 'But there is another source of confusion. To many surgeons Paget's disease is a clinical entity whose chief characterization is about the nipple and areola. In the preparation of this writing we carefully read the accounts of disease in twenty textbooks of surgery and

in the ampulla of the terminal duct and that it spreads along the duct to the surface and to the deeper parts. It extends over the nipple and the areola and at times well out onto the integument of the breast. This new growth is composed of 'Paget's cells', and unless these cells are present one is not dealing with a true case of Paget's disease. These cells are characteristic. They begin in the malpighian layer and are peculiar large hyperchromatic cells with a decided malignant appearance. (2) Occurring deeper in the mammary substance is a carcinoma of a small duct. This has all the clinical significance of any other type of mammary carcinoma.



466—Showing Paget's disease of the nipple that began as a granular ulceration of the nipple slowly spreading onto the areola and out over the skin. At times the area is covered by a dry scaly hard integument, but at other times the entire area is moist. It has a mucoid secretion and bleeds easily.

astonished to find that it was exceptional to find a correct or adequate statement regarding it. Most common mistakes were the statement that the disease was squamous cell carcinoma of the areola or that Paget's disease was the result of the invasion of the skin by carcinoma of the

**Definition and Pathology**—Paget's disease of the nipple to the best informed student of the subject signifies a complex disease process. It represents two entirely different and entirely disconnected biologic processes occurring simultaneously in the mammary tissue and in its integument. (1) It is believed by some that the disease commences in the epithelial lining of the ampulla of one of the terminal ducts. Others maintain that it commences

in the ampulla of the terminal duct and that it spreads along the duct to the surface and to the deeper parts. It extends over the nipple and the areola and at times well out onto the integument of the breast. This new growth is composed of 'Paget's cells', and unless these cells are present one is not dealing with a true case of Paget's disease. These cells are characteristic. They begin in the malpighian layer and are peculiar large hyperchromatic cells with a decided malignant appearance. (2) Occurring deeper in the mammary substance is a carcinoma of a small duct. This has all the clinical significance of any other type of mammary carcinoma. Handley,<sup>3</sup> one of the greatest students of the subject maintains that Paget's disease commences primarily as a superficial carcinoma of a duct of the breast and that as it grows a disturbance is created in the lymphatics of and about the nipple and areola which in turn is responsible for the formation of the neoplastic cells of the integument. Cheatle<sup>4</sup> maintains that in many instances there is no demonstrable connection between the deeper mammary carcinoma and the neoplasm of the skin. At any rate one thing of great practical importance must be kept in mind namely if biopsy of the skin of the areola or nipple shows Paget's cells there is always a deeper lying mammary tumor present even though the

clinician cannot find it on palpation. This brings the subject down to the practical problem of correct treatment based on exact pathologic findings.

**Diagnosis**—The diagnosis is made on the presence of a slightly ulcerating granular weeping itching area of the nipple and areola. If in the presence of this area a tumor is found deeper in the breast having signs of malignant growth the diagnosis of Paget's disease is practically certain. Frequently no tumor is palpated in the breast in this case it is necessary to take a *biopsy* specimen from the ulcerating area to establish the presence of Paget's cells before a positive diagnosis can be made. This latter picture is frequently confused with simple eczema but eczema is usually bilateral and occurs in young persons. Paget's disease is always unilateral.

**Prognosis**—The prognosis is good because the mammary carcinoma is very slow to metastasize to the axillary nodes; i. e. it is of low grade malignancy while still confined to the breast. If metastatic disease once fills the axilla to any appreciable degree the prognosis is poor because it then has acquired all the malignant characteristics of other mammary carcinomas.

**Treatment**—The treatment is radical amputation of the breast and removal of the axillary contents. Mistakes are commonly made by not establishing the exact diagnosis and as a consequence the small deeper undiagnosed mammary cancer may not become manifest clinically for several years. This is a loss of valuable time so important for cure.

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### III SARCOMA OF THE BREAST

**Definition**—Sarcoma of the breast is a rare malignant tumor of the mammary

gland which arises usually from the periductal connective tissue.

**Pathology**—Sarcoma of the breast arises from true mammary tissue and also from tissues incidentally resident in the mammary. The latter type should not be considered as true mammary sarcoma as it may be of nerve (neurogenic sarcoma), fat (liposarcoma) or lymphoid origin (lymphosarcoma). However, these growths are generally included in the sarcomas of the breast as they belong there anatomically. True sarcoma of the breast arises usually from a pre-existing fibroadenoma which under the influence of certain unknown factors has changed from a benign to a malignant process involving chiefly the connective tissue.



FIG. 46.—Sarcoma of the breast. The bulky tumor grew to this size in four months. It was preceded for many years by a small fibroadenoma.

elements of the fibroadenoma. Usually the patient reports that after the tumor had been present for many years sudden rapid growth took place (Fig. 467). This is the indication that the malignant metamorphosis has occurred. Growth is astonishingly rapid and the tumor soon becomes the size of an orange, later the size of a child's head. By this time central necrosis has usually occurred from lack of blood supply and there is a bulky, foul gray, sloughing, deeply excavated tumor. Hemorrhage is common in those tumors which arise from fibroadenomas. Although the neoplastic elements are chiefly from the connective tissue the glandular structures frequently are found scattered through the bulky tumor. In fact this type of sarcoma occasionally

also has a carcinoma present within the breast. The presence of chondromas and osteomas is not unusual in a series of cases of any size. The breast sarcomas could be divided on a pathologic basis as arising from

1 A pre-existing fibroadenoma of the breast. This is the most common type.

2 A pre-existing neurofibroma. These benign tumors undergo mutation and assume all the malignant qualities. Their origin is the nerve sheath but usually they are found in patients with other stigmas of von Recklinghausen's disease such as café au lait spots on the integument, the presence of multiple neurofibromas, fibroma molluscum, plexiform neuroma, etc.

3 A pre-existing intracanalicular fibroadenoma. This tumor occasionally gives rise to a bulky cystosarcoma phyllodes or "giant" intracanalicular myxoma. The tumor is characterized by its bulk, its cysts and its benignancy.

4 The presence of lymphoid tissue in the breast, especially in the tail of the breast. This has undergone malignant changes and is now lymphosarcomatous.

**Diagnosis**—The diagnosis is based on two main points which are pathognomonic, namely, the presence for many years of a tumor and the sudden and rapid growth of this tumor. It soon grows to a large bulky mass fungates through the skin and metastasizes to the chest, killing the patient.

**Prognosis**—The prognosis of mammary sarcoma is very grave. Much depends on which type of origin and what grade of malignancy the tumor represents.

**Treatment**—The treatment consists in radical mastectomy. The tumor does not metastasize by the lymphatic route to the axilla, but it frequently happens that separate tumor nodules are present in the region of the original tumor, especially in the low axilla; therefore, wide excision is imperative. The modern treatment of lymphosarcoma and liposarcoma is by irradiation.

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#### RADIOTHERAPY IN CANCER OF THE BREAST

The use of radiotherapy in cancer of the breast is based on the power of radium and x rays to inhibit the growth and reproduction of living cells. Both cancer and normal cells may thus be damaged although cancer cells are usually more readily affected. The neoplasia is not removed mechanically, but is destroyed *in situ* the body disposing of the debris. For instance the fungating part of an irradiated cancer of the breast may be sloughed off while its infiltrating base must be absorbed by phagocytes and carried away through the lymphatics. The physiologic and pathologic conditions of the tissues surrounding the cancer and the general health of the patient therefore influence the result of the treatment. The larger the cancer the larger the area of tissue which is irradiated the greater is the taxation of the patient's general health.

**Radiosensitivity of Tissues Surrounding Cancer**—As irradiation is not limited to the cancer but includes the surrounding tissues, consideration of their resistance to irradiation is important. Normal and cancer cells nearing mitosis and normal tissues and cancers in which the cells divide frequently are believed to be especially sensitive to irradiation. Normal tissues and cancers composed of undifferentiated cells which reproduce rapidly have been regarded as more radiosensitive than those consisting of cells showing greater differentiation and less reproductive activity. Yet among 33 mammary carcinomas irradiated at the Presbyterian Hospital, New York, and classified microscopically, more well differentiated than poorly differentiated carcinomas regressed after similar doses of x-ray therapy. There are therefore other additional factors which influence radiosensitivity. The destructive action of irradiation causing death of the irradiated tissues may be recognized clinically when the natural life cycle of the cells composing these tissues has been terminated. Thus the death of short lived epithelium may be appreciated early while that of connective tissue, cartilage or bone takes longer to become apparent. A breast which has been intensely irradiated with consequent shedding and subsequent healing of the irradiated skin may grossly appear normal yet on microscopic examination will show obliterating endarteritis and hyalinization of the connective tissue. Such tissue cannot tolerate additional irradiation and has little resistance to infection if operated on or traumatized it heals poorly and may break down. Because of this lack of resistance if intense irradiation is given before mastectomy the incision should be made outside the heavily irradiated area.

**Radiosensitivity of Cancer**—The inherent radiosensitivity of most cancers of the breast is greater than that of the surrounding normal breast tissue. After intense irradiation there usually is a gross reduction in the size of the breast tumor while the normal breast shows much less damage. In a series of 52 patients with mammary cancer irradiated preoperatively or treated only by x-rays at the Presbyterian Hospital, New York, the breast tumor regressed markedly in 67 per cent of those treated without much gross change in the irradiated breasts. This reduction was noted in nearly 90 per cent of the tumors which were 3 cm. or less in diameter and in 60 per cent of

those which were 6 cm or more in diameter. The gross clinical reduction was corroborated microscopically. In 9 cases the appearance of the growth in the biopsy specimen before irradiation was compared with that in the mastectomy specimen 2 to 394 days after the last x ray treatment. In these there was noted a marked reduction in the number of mitoses atypical mitoses gigantic or on the other hand pyknotic nuclei vacuolated cytoplasm fibrosis hyalinization of the stroma and occasionally foam cells and cholesterol crystals. In spite of gross and microscopic signs of marked radiation damage to the tumor recognizable cancer cells could be demonstrated in every one of the specimens showing the true radioresistance of these cancers and the difficulty of curing them by these doses of x ray. The result was undoubtedly related to the dosage and microscopically the evidence of radiation damage with greater dosage was more severe. The maximal dosage tolerated by the normal tissues should be given if x ray is chosen as the sole method of treatment as a correlation between definite microscopic types of breast cancer and radiosensitivity are as yet not available.

**Relation of Radiosensitivity to Radiocurability.**—Radiosensitivity should not be confused with radiocurability. Radiosensitivity is denoted by the immediate regression of a mass to a given dose of radiation. Radiocurability depends not only on the inherent radiosensitivity of the cancer and of the surrounding normal tissues but also on the accessibility of the cancer its natural clinical course if untreated the general condition of the patient the technic of radiotherapy the correct dosage and other conditions.

**Relation of Radiocurability to Accessibility.**—The effectiveness of radiotherapy in cancer of the breast like that of radical mastectomy, is practically limited to the area which is adequately treated. Cancer cells which are outside of this area are not influenced or are affected very little. For instance irradiation and subsequent regression of the primary tumor in the breast will not influence distant metastases which have not been irradiated. An exception to this rule that the effect of radiotherapy in cancer of the breast is limited to the areas which have been adequately irradiated is found in the regression of skeletal metastases from mammary carcinoma which have not been irradiated directly but which regress after the production of an artificial menopause by irradiation of the ovaries. With this exception radiocurability of cancer of the breast depends on adequate radiation dosage to the primary breast tumor axillary metastases and all other extensions and metastases. It is self evident that it is impossible to appreciate clinically early microscopic foci of cancer and even larger extensions and metastases may also escape recognition and treatment. The larger the primary breast tumor and the regional involvement, the more likely that local extensions and distant metastases may occur and may escape treatment. The five year survival of 78 patients treated by radical mastectomy and postoperative roentgen therapy at the Presbyterian Hospital in New York was found to vary directly with the extent of involvement of the breast and axillary glands. Among 33 patients with inoperable cancer of the breast treated only by x rays at the Presbyterian Hospital during

1938 and 1939 there are 8 who have been free from clinical evidence of cancer for five or more years. None of these patients ever presented any signs suggesting distant metastases and no patient with distant metastases was completely free from signs of cancer for five years although several survived the five year period.

**Relation of Radiocurability to the Natural Clinical Course of Cancer.**—The natural clinical course of the cancer has a decided influence on the result of radiotherapy. Patients with cancer which progresses slowly continue to show this tendency irrespective of the treatment, while others with more acute and malignant cancer often die in spite of radical therapy. A patient, who twenty four years previously had refused radical mastectomy, avoided all medical aid until painful skeletal metastases forced her to seek relief by x ray therapy. By this time the cancer had completely destroyed the affected breast and had invaded the adjacent chest wall. Her long survival might have been mistakenly credited to radical mastectomy or radiotherapy had she been treated by these means. In one patient radical mastectomy and postoperative x ray therapy were not instituted until twelve years after the breast tumor had been noted. In another the same therapeutic procedures were carried out one month after she had noted the tumor. The first patient was well at the end of seven years and the second died five months after mastectomy. Neither the successful result in the first nor the failure in the second can be credited wholly to their respective treatment. The natural clinical course of the cancer helped in the first and interfered with successful treatment in the second case. It should be remembered that in 100 untreated cases of cancer of the breast, an average survival period of forty months from initial symptoms to death has been reported by Daland.

**Relation of Radiocurability to Infection.**—Therapeutic doses of x rays and radium rays have practically no effect on bacteria. Superficial infections in cancer of the breast may be carried off by the radiation slough in deep and undrained infections, vigorous radiotherapy may increase the breaking down and may facilitate deeper bacterial invasion of the tissues. This has no relation to sterile tumor necrosis. Usually such broken-down masses are gradually absorbed under x ray therapy.

**Relation of Radiocurability to the General Condition of the Patient.**—Aged debilitated persons and patients with diabetes arteriosclerosis and heart disease frequently do not tolerate the intense reaction resulting from the administration of large doses as employed when permanent arrest of cancer by radiotherapy is attempted. This limiting circumstance does not pertain to palliation in which small doses are given as needed and as tolerated by the patient.

**Technic of Radiotherapy.**—*Methods of Approach.*—The site of the primary tumor in the breast as well as its metastases in the axillae and in the supraclavicular and intercostal regions may be attacked by x ray or radium either applied externally through the skin or internally. In the latter method needles containing radium element or radon (radium emanation gas) or tung gold capillaries filled with radon (radio-

seeds) are inserted interstitially into and around the masses of cancer. The needles are removed after the desired number of hours of irradiation. The seeds are permanently buried in the tissues. The radon is used up in one month and the seed if not extruded through the skin becomes inert and is encapsulated like any foreign body.

The external approach has the advantage that large areas suspected of harboring microscopic foci of cancer may be included in the field of intensive irradiation. In this method the deepest parts of the neoplasm are farthest from the source of the rays; the intervening tissues absorb a great deal of the radiation applied on the surface, and the amount of x rays finally reaching the cancer cells may be inadequate for permanent clinical arrest of the cancer. It seems particularly difficult to administer by external x ray therapy with voltages up to 200 kv., cancericidal doses to deep-seated lymph nodes. A tumor in a pendulous breast may be cross fired through four or more portals and the radiation dose reaching the tumor thus raised to a maximum tolerated by the surrounding breast tissue. In mediastinal or internal mammary lymph node metastases such cross firing is impracticable and such doses are also not given for fear of injuring the adjacent radiosensitive lung and pleura.

The intensity of interstitial irradiation is greatest in the immediate vicinity of each needle or seed and quickly diminishes with increasing distance from the source. Success depends on accurate placement of these radiating foci; otherwise some parts may be over-irradiated while in others the cancer cells may escape unharmed. The use of this method is therefore limited to accessible, relatively small growths that have not invaded the neighborhood of vital structures. For instance when cancer has invaded the apex of the axilla the danger of injury to axillary vessels and nerves practically precludes the successful application of this method.

**Criterion of Correct Dosage.**—Irradiation in cancer of the breast may be given with intent to cure or only to palliate. If an attempt is to be made to cure the patient the maximal amount of radiation which may be tolerated by the adjacent normal tissues is given in all cancers as the cancericidal dose for particular types of breast cancer has as yet not been established. The treatment may consist of a single or of a series of radiation exposures. The treatment should be completed before the appearance of retrogressive radiation changes in the normal tissues. Once finished it should ordinarily not be repeated as a cure by second treatment occurs rarely and there is great likelihood of permanent radiation damage to the normal tissues. Palliative radiotherapy on the other hand is administered in small doses which may produce growth restraint but do not permanently arrest the growth of cancer. This radiation is repeated as needed and tolerated by the patient. The dosage is dictated not by the desire to cure but by consideration of the tolerance and comfort of the patient. Large doses which may produce severe local or general reactions are avoided.

It is difficult to estimate the correct dosage which in a given case will cure breast cancer. In 33 cases of cancer of the breast treated preoperatively with x rays at the Presbyterian Hospital, New York, cancer cells

were found microscopically in the mastectomy specimens 2 to 334 days after the last x ray treatment though grossly these specimens did not show any evidence of persisting cancer. The dosage used in these cases was only a little less than that applied in the 8 out of 35 inoperable cases treated in 1939 and 1940 in which the patients have been free from clinical evidence of cancer for five years or longer after x ray therapy. There is no assurance that in some of these eight patients temporarily quiescent cancer cells may not again start growing in the future. A five year freedom from clinical evidence of cancer has been accepted as the criterion of cure for radical mastectomy. After radiotherapy the site of the primary tumor and regional nodes remain in situ in contradistinction to the removal of these possible sources of future growth by the radical operation. In spite of this important difference however and in order to have at least a somewhat comparable standard for evaluation of these two methods of treatment it seems fair to adopt a five year clinical freedom from cancer as a criterion of clinical cure by radiotherapy. The average dosage estimated to reach the site of the cancer in the 8 clinically cured cases was calculated to vary between 5000 and 6000 r or about nine to ten times the dose which if applied to the skin in one exposure would produce a mild erythema. Perhaps this is the correct dosage for cancer of the breast.

**Indications for Radiotherapy.**—Radiotherapy of cancer of the breast may be employed as the only treatment or combined with operative removal of the primary tumor and axillary metastases.

**Radiotherapy in Inoperable Cancer of the Breast.**—The value of radiotherapy in inoperable cancer of the breast is generally accepted. Practically no other form of treatment is available in these cases except in the rare instances in which destruction by heat or caustic might be preferable. With the proper use of radiotherapy ulcerated surfaces may be healed, large tumors may be reduced in size, attachments to the sternum and ribs may be absorbed, pain due to pressure on nerves or to bone invasion may be relieved, the general condition of the patient may be improved and at times the disease may be arrested. This may be done with interstitial or external application of radium or roentgen therapy.

Radium needles inserted into the primary cancer in the breast and the regional lymph node areas gave good results in the hands of Geoffrey Keynes of London. These results were not obtained by others using his method and in recent years interstitial radium has not been used much in cancer of the breast in the United States.

X ray therapy has been administered for inoperable mammary cancer for over forty five years. Regression of the primary tumor in the breast after x ray therapy does not determine the progress of the disease as a whole if distant metastases are present. It is more the latter factor which influences the clinical course of the case, and if distant metastases are present the x ray dosage to the breast tumor is moderate as it is given for symptomatic relief such as to heal ulcerations, relieve pain, etc., and cure is not attempted. If on the other hand the disease clinically has not spread beyond the breast and axilla and an attempt is to be made

to control it permanently by radiotherapy maximal x ray doses to the breast and axilla are indicated. This type of treatment should not be applied until careful clinical and radiographic search for local extensions and distant metastases suggests that the disease is limited to the breast axilla and perhaps one supraclavicular area and that the patient will tolerate the treatment. Once this has been decided accurately installed daily x ray exposures are applied cross firing the tumor in the breast axilla and if need be in the supraclavicular area. This should be done by someone familiar with the disease and the physical distribution of the irradiation applied to these anatomical parts. Each treatment should be done as carefully as when a surgeon undertakes to do radical mastectomy. Only if treatment is carried out in this manner may one hope for better results.

**Radiotherapy in Operable Cancer of the Breast.**—In view of the decided influence which the extent of the cancer at the time of treatment has on the results which may be expected from radiotherapy in operable cancer of the breast it is not surprising that the results of this treatment in cancer limited to the breast have been better than those just quoted in inoperable cases. However radiotherapy in these cases is still experimental. Months after irradiation of a cancer of the breast with resulting marked diminution in size microscopic examination of a specimen removed for biopsy may reveal the presence of well stained cancer cells and mitoses. While long-continued clinical freedom from symptoms may result from irradiation late reactivation of the primary growth and metastasis cannot be excluded. Radical mastectomy is therefore still the accepted method of treatment in early operable cases in which the disease is clinically limited to the breast. A patient whose poor general condition contraindicates surgical intervention should be given radiotherapy. Clinically very malignant rapidly growing inflammatory cancer common in young women especially during pregnancy is also best treated by irradiation. Radiotherapy is preferable for this group in spite of poor results as radical mastectomy is frequently followed by wide dissemination of the disease.

**Radiotherapy of Metastases.**—Skin metastases can usually be made to disappear by radiotherapy. Ordinarily they reappear although in exceptional cases even cancers "en cuirasse" may be held in check for several years. Metastases in operative scars may be difficult to control as occasionally necrosis of the scar results following vigorous irradiation with cancericidal doses.

Röntgen therapy of skeletal metastases is usually followed by diminution of pain and frequently by recalcification of areas of bone absorption. If a clinical diagnosis of skeletal metastases has been made x-ray therapy should be given even if x-ray films fail to show the metastases. In 11 such patients followed by monthly x-ray films at the Montefiore Hospital New York a diagnosis of skeletal metastases was made and x-ray therapy to the affected areas started from one-half to twelve months before the x-ray films finally showed the suspected skeletal metastases. In addition to the radiotherapy Brünchwig advises the daily administration of 10 to 15 Gm. of calcium gluconate over a 4 to 6 week period of time. Support for a weakened spine

and relief of pain caused by pressure on a partially destroyed vertebra may be obtained by the use of spinal braces or a stiff corset which reaches at least up to the angle of the scapula. This help is especially useful before healing secondary to the x-ray therapy. In spite of improvement of these patients after radiotherapy, the majority die less than a year after the onset of symptoms. In exceptional cases however extensive metastases have been controlled for from a few to twenty years and bedridden patients have obtained economic restitution. Improvement in non irradiated skeletal metastases has been noted after castration incidental to roentgen therapy of metastases in the pubic and iliac bones. Roentgen castration is usually carried out in skeletal metastases from cancer of the breast in addition to radiotherapy directed over the metastases in the bone.

Röntgen therapy is only of temporary palliative value for the majority of pulmonary metastases as they usually occur in the terminal stage of the disease. In some cases however metastases in the lungs and pleurae have been held in check for five and six years though eventually death was caused by the disease.

Metastases in the abdominal viscera respond only slightly or not at all to roentgen therapy and usually progress rapidly until the end.

Metastases in the brain spinal cord and retina have been temporarily controlled by roentgen therapy. While for a time there is regression of symptoms they usually recur within a few weeks or months and then further treatment is futile.

**Preoperative Roentgen Therapy.**—As a companion of the microscopic structure of the preirradiation biopsy material and the 9 postirradiation mastectomy specimens mentioned earlier showed a marked reduction in the number of mitoses monster and shadow cells and other evidences of radiation damage it does not seem too far fetched to think that vigorous preoperative radiotherapy in tumor doses of 1000 r or over may tend to reduce the viability of the tumor and the likelihood of local persistence and distant spread of the cancer. There is only little support for the belief however that 1000 r or less will do more than temporarily reduce the number of mitoses. Preoperative radiotherapy should be limited to those few cases in which a definite decision cannot be made as to whether the case is operable or not. A rigid application of the rules of operability will probably lead to classifying them as inoperable and transfer them to radiation therapy instead of trying to combine both methods. If full radiation dosage is given preoperatively a period of delay lasting for six to eight weeks that is until every vestige of erythema has disappeared is essential before mastectomy may be performed. In regard of this precaution has resulted in non-healing wounds.

**Postoperative Roentgen Therapy.**—As shown by microscopic study of preoperatively irradiated patients and the five year follow-up statistics of non-operated patients the cancericidal x-ray dosage for most carcinomas of the breast is much higher than that which is usually applied to the thin poorly nourished post-mastectomy skin flap covering the chest and axilla and over the supraclavicular intercostal internal mammary and paravertebral chains of lymph nodes. Therefore one cannot hope ordinarily to destroy the postoperative

x ray therapy the cancer remaining in these areas after the operation. Nevertheless statistics which show a larger proportion of five year survivors when radical mastectomy is followed by x ray therapy suggest that a certain amount of temporary growth restraint may be obtained by lesser x ray dosage. We do not advise the routine use of postoperative x ray therapy but apply it in occasional cases in which the operator believes that he did not remove the entire cancer. The radiation is then applied to the supraclavicular and internal mammary lymph node chains in the hope of causing temporary growth restraint in these areas. The mastectomy and axillary regions are irradiated only if the operator believes that cancer may persist in these areas.

**Irradiation of the Ovaries.**—Roentgen castration of all women with cancer of the breast before the menopause has been advised. The only definite proof of benefit from this procedure is found in the regression of non irradiated skeletal metastases in other cases it should not be carried out routinely.

**Summary.**—Successful radiotherapy of cancer of the breast is based on familiarity with the disease, appreciation of the factors governing the relative radio sensitivity of cancer and the tissues surrounding it, as well as the correct irradiation of all parts of the growth.

Radiotherapy is the treatment of choice in inoperable and metastatic cancer of the breast. Similar treatment in operable cancer clinically limited to the breast is as yet experimental and is justified only in certain exceptional cases. Radical mastectomy being preferable, provided rigid classification of operable and inoperable cases is carried out. Preoperative and postoperative roentgen therapy may be of value in some cases for temporary growth restraint of the cancer.

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## TRAUMATIC FAT NECROSIS, TUBERCULOSIS AND SYPHILIS OF THE BREAST

### TRAUMATIC FAT NECROSIS

**Definition.**—Traumatic fat necrosis of the female breast is a benign disease which occurs as the result of severe trauma to a very fat breast. As the clinical signs and symptoms closely parallel those of carcinoma, the disease is commonly mistaken for cancer of the breast.

**Etiology.**—The lesion occurs only in breasts which are unusually corpulent. The average weight of the patients in the twenty cases reported by Lee and Adair was 176 pounds. An injury of severe nature takes place causing extravasation of blood into the fat tissue of the breast. The injuries have frequently been caused by the introduction of long hypodermoclysis needles following some severe operation. The large needle punctures one of the numerous veins of the breast permitting extravasation of blood into the interductal areolar tissue and into the thick fat pad overlying the mammary tissue. The lesion results also from such severe injuries as a fall down a flight of stairs. In one instance the patient fell down stairs holding a picture frame under her arm. The corner of the frame ran into the breast without breaking the integument but resulted in the production of a marked ecchymotic area.

**Pathology.**—Necrosis of the fat tissue occurs both as a direct result of injury and also as a result of hemorrhage in the local tissues. Necrosis occurs very soon after the injury. Many giant cells appear and have been seen in tumors in as short a time as five weeks. There is lymphocytic infiltration associated with a marked production of fibrous tissue. One feature is that of an obliterating endarteritis. Frequently, numerous small cysts of fluid fat are scattered through the lesion. Later on the mass contracts; there is a considerable growth of new spin-



dle fibroblasts, and more and more fibrous tissue forms. The lesion may contain calcium deposits, and at times the wall of a cyst may be calcific or the cyst contents may be fluid oil and admixed with small stones of calcific material.

**Symptoms and Diagnosis.**—After the hemorrhage which follows the injury has been absorbed, a painless, stony-hard tumor forms. It may become attached to the overlying skin, retract the nipple, deform the shape of the breast (Fig 468) and even be attached to the deeper structures, such as the pectoralis major muscle. The diagnosis is based on (1) the history of a severe injury which occurs in (2) a very fat breast.



Fig 468—Traumatic fat necrosis of the female breast showing the characteristic puckering and skin attachment. A tumor is present possessing all the clinical signs of cancer. This benign tumor resulted from the introduction of hypodermoclysis needles beneath the breast.

(3) A painless, stony-hard tumor is present which (4) causes attachment to the skin, retraction of the nipple and deformity of the breast.

**Prognosis and Treatment.**—As traumatic fat necrosis of the breast is a benign lesion, local removal of the tumor will effect a cure.

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## TUBERCULOSIS OF THE BREAST

### (*Tuberculous Mastitis*)

**Definition.**—Tuberculosis of the breast is a rare lesion (which is becoming rarer) caused by an infection of the mammary tissue with the tubercle bacillus. It was first described by Sir Astley Cooper in 1829.

**Etiology and Pathology.**—The tuberculosis in this instance is thought by some to be primary in the breast, the result of a blood-borne infection. Another school of thought stoutly maintains that all mammary tuberculosis is secondary to tuberculosis in other parts, such as rib, lung, pleura, mediastinum sternum, cervical or axillary node

involvement. The latter view is more common and is explained on the ground of retrograde lymphatic extension. The axillary lymph nodes are involved in about 60 per cent of the cases. The tuberculous mastitis is usually a localized process. The lesion develops to the stage of tissue liquefaction and the formation of a true tuberculous abscess. The abscess burrows up through the breast, appearing by one or more sinus tracts at the surface of the skin, where it breaks discharging the characteristic tuberculous abscess pus.

**Symptomatology and Diagnosis.**—A soft tumor mass is present in the breast. The lesion is painless except immediately before

the rupture of the abscess when it again becomes painful. The differential diagnosis must be made chiefly from a fungating carcinoma from actinomycosis and from pyogenic mastitis. About the sinus tracts a deeper pigmentation takes place on the skin surface. The nipple is commonly retracted especially if one of the fistulas appears within the areola. The clinical diagnosis is frequently difficult but is based on the multiplicity of sinus tracts on the discharge of the characteristic tuberculous pus on the presence of a soft breast tumor on the microscopic proof of the presence of tubercle bacilli in the smear and on the x-ray film demonstration of pulmonary rib or mediastinal tuberculosis.

**Prognosis and Treatment.**—The prognosis is usually good depending however on the extent of the disease process in the other parts of the body. Frequently local surgical removal of a section of the breast is not curative because the sinus tracts are tortuous and the operator is quite apt to leave behind an area of tuberculous mastitis in which another abscess will develop later. Local mastectomy usually effects a cure unless the axillary nodes are involved in which case an axillary dissection is indicated. It is not necessary, however to remove the pectoral muscles. It is highly important that the operation be followed by general hygienic treatment.

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#### SYPHILIS OF THE BREAST

**Definition and Etiology.**—Syphilis of the breast consists of one or multiple lesions of the breast or nipple caused by infection with the *Treponema pallidum*. It is a rare local manifestation of a general disease. In a series of approximately 4000 patients with lesions of the breast admitted to the Memorial Hospital in New York City there were 2663 cases of cancer, 180 of fibroadenoma, 16 of sarcoma, 20 of Paget's disease, 1000 of subacute and chronic mastitis and only 2 (0.05 per cent) of syphilis of the breast.

**Pathology.**—The form taken by the le-

sion is dependent on the stage of the syphilitic infection. 1 *The primary chancre* of the breast is usually localized on the nipple, is usually bilateral and is the most common syphilitic lesion. In days past when wet nursing was frequently employed it was not uncommon for a wet nurse with syphilis to infect the mouth of an infant who in turn might transmit the infection to his parents. The reverse of the process was also true. 2 *The secondary stage.* The skin of the breast is frequently the site of syphilitic eruptions. Mucous patches may occur about the nipple. 3 *The tertiary stage.* The gumma is an extremely rare manifestation of a syphilitic lesion. Among approximately 7000 cases of breast lesions at the Memorial Hospital there was but one gumma. The gumma is an intraparenchymatous lesion. At times it appears in a subareolar position causing ulceration and sometimes total destruction of the nipple.

**Diagnosis.**—The chancre of the nipple and the subareolar ulcerating form of gumma are difficult to differentiate from Paget's disease. The characteristic appearance of chancre however will aid in distinguishing it. The diagnosis can be easily verified histologically by biopsy and also by the Wassermann and Kahn tests. A therapeutic test with doses of arsphenamine will also help in the diagnosis. The gumma commences as a firm localized mass gradually pressing against the skin from beneath causing a dusky red and later a localized red area which becomes purple. The tumor at this stage softens, becomes fluctuant and if cut into will exude typical necrotic material. The wound is grayish, has overhanging edges, is unhealthy in appearance and will not heal. The diagnosis of syphilis of the breast is based on the anamnesis including the history of exposure, primary and secondary manifestations, miscarriages, serological reactions, biopsy, dark field examinations, etc.

**Prognosis and Treatment.**—The prognosis is favorable for a complete cure of the lesion if the proper antisyphilitic therapy is carried out. This should include penicillin.

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## DISEASES OF THE MALE BREAST

In considering the diseases of the male breast it must be borne in mind that the breast in the male is a rudimentary organ yet occasionally most all the diseases common to the female breast may be observed.

**Anomalies**—The congenital anomalies of the breast are amastia (absence of the breast) polymastia (supernumerary breasts) athelia (absence of the nipple) and polythelia (supernumerary nipples). These are rarely observed in the male.

**Gynecomastia** which may be defined as excessive size of the mammary gland or glands in the male may occur in youth young adult life or middle life and is either idiopathic or associated with disturbances of the sexual glands inflammations such as mumps or the result of direct trauma on the breast. The treatment should always be conservative operative intervention (resection of the breast leaving the skin and nipple or mastectomy) being resorted to only if the breasts cause mental or physical suffering. More recently x-ray therapy has been suggested but this seems to be of doubtful value. Testosterone propionate the male sex hormone is of some value and should be tried before resorting to surgical treatment.

**Infections and Inflammations**—Infections and inflammations may occur in the male breast but occur much less frequently than in the female. All the pyogenic infections common to the skin may occur on the breast and nipple such as furuncles boils cellulitis and even abscesses. Inflammatory lesions due to pyogenic infections may cause eczematous conditions of the nipple and areola sometimes giving rise to infection of the ducts or acute mastitis.

Acute mastitis is rare in the male except soon after birth that is it may occur from the fourth to the twentieth day of the newborn infant's life or at the time of puberty. It manifests itself by painful swelling redness and tenderness and at times even by a discharge of a milk like substance. It usually requires no treatment especially no massage but the patient may be made comfort-

able by the use of hot or cold antiseptic applications. Injury to the male breast some times leads to acute mastitis with or without abscess formation.

The treatment of infections of the male breast should follow strict surgical principles. The use of soothing applications antiseptics or antiseptic ointments and if abscess formation occurs incision and drainage constitute the course to follow.

Chronic interstitial mastitis or chronic hypertrophic mastitis is a rare distinct clinical entity and may occur at any time from adolescence to old age. The causative factor is unknown but it has followed in the wake of acute mastitis and injuries. This disease may be diffuse or localized. Diffuse involvement is noted particularly below the nipple or areola and when localized is in the form of hard nodules which are not encapsulated. Pain may or may not exist and may be variable in its severity.

The proper treatment consists of soothing applications or ointments containing ichthyl mercury or iodine and the administration of iodids internally. If palliative treatment does not suffice after a reasonable time mastectomy may be necessary for the relief of pain.

The granulomatous infections such as tuberculosis syphilis and actinomycosis have occasionally been observed in the male. These lesions are usually of a low grade inflammatory nature with the formation of indurated nodules or diffuse infiltrations which in the period of weeks or months may cause some pain and swelling redness of the skin and finally ulceration with sinus formation.

The importance of these granulomatous processes is that occasionally, before the breaking down and the formation of sinuses these tumorous masses may simulate malignant disease in that the skin may be adherent and retracted the tumor mass may be poorly defined and the lymph nodes in the axilla may be enlarged. The proper histologic and pathologic examination of tissue and pus will make the diagnosis certain.

The treatment of tuberculous mastitis is the general hygienic regime of all tuberculous patients including heliotherapy and conservative surgical procedures for the eradication of the local disease.

**Syphilis of the Breast**—Syphilis of the breast may present itself in the form of cutaneous lesions or gummas. Characteristics of syphilitic manifestations such as gummas can be corroborated by complement fixation tests or therapeutic tests of mercury, bismuth, iodids and other specific remedies which usually cause a prompt regression of the disease.

**Actinomycosis**—Actinomycosis may be differentiated from other lesions by the finding of sulfur like granules in the pus from abscess cavities or sinus tracts which will show the presence of actinomycetes. Conservative surgical treatment such as excision of the abscess cavity or eradication of the sinus tracts or ulcerating areas together

the breast areola or nipple are those common to the skin in general that is the basal cell epithelioma, squamous cell epithelioma and malignant melanoma.

Tumors in the breast proper include the fibroma, lipoma, angioma or lymphangioma, fibroadenoma, cystic adenoma, serous cyst, retention cyst, galactocele and papillary cyst. Malignant tumors of epithelial origin are duct carcinoma (at times presenting the appearance of Paget's disease), adenocarcinoma and papillary carcinoma. All may at times be spoken of as scirrhus or medullary type depending on the amount of connective tissue proliferation in the tumor.

Of the connective tissue tumors there are various types of sarcoma. The fibrosarcoma



Fig 469.—Carcinoma of the left breast, with metastases to the axilla in a man aged fifty-three. It was treated surgically and by radiation in 1930. He died from metastases to the lung and mediastinum five years and one month after admission to the hospital.

with the use of copper sulfate, iodids and irradiation is recommended. Since the introduction of the sulfanilamide preparations a few isolated case reports of treatment of actinomycosis with this drug have been recorded with marked beneficial results. More recently penicillin has proved to be a valuable agent in the treatment of this disease.

**Malignant and Benign Tumors**—Malignant and benign tumors of the breast proper may be divided into those originating in the epithelial cells and those originating in the connective tissue cells. The benign tumors which may occur in the skin, areola or nipple are the fibroma, fibropapilloma, angioma, nevus and sebaceous cyst. The malignant tumors which may involve the skin of

(spindle cell) is the most common and then the adenosarcoma depending on the presence of epithelial elements in the tumor. Occasionally rare types of sarcoma such as lymphosarcoma, neurogenic sarcoma, osteochondrosarcoma, endothelioma and liposarcoma have been described.

Tumors benign and malignant may occur in the male breast at any time from the twentieth year to old age.

**Diagnosis**—The differential diagnosis between benign and malignant tumor of the male breast is at times very difficult. Generally the characteristics of benign tumors may be described as follows: tumorous masses which vary in size from a few millimeters to several centimeters in diameter

As a rule they are sharply defined firm in consistency movable on the underlying tissue and beneath the skin and slow in growth. In the case of cysts a sense of fluctuation may be obtained and no shadow is cast on transillumination if they contain clear fluid. If the fluid is turbid or bloody opacity to transilluminated light is observed. Other tumors give shadows depending on the density of the tissue from which they are derived. However the transillumination of the male breast while valuable is very difficult because of the small size of the organ.

At times most all of these characteristics may be encountered in a malignant neoplasm of the male breast but more often they are tumors varying in size which are not tender are hard in consistency and poorly defined tending to merge with the surrounding breast tissue. When seen later they are adherent to the skin as is evidenced by the pig skin or orange peel appearance and still later they may be adherent to the underlying tissue with enlargement of the axillary nodes which are hard in consistency. Ulceration pain and bleeding as a rule are late symptoms.

The benign tumors when favorably situated sharply defined and not too large may be removed by local resection or enucleation. However the correct diagnosis of diseases of the male breast may be so obscured that mastectomy is preferable.

**Treatment**—The treatment of malignant diseases of the male breast should always be radical especially when they are seen early that is when the tumor involves the breast with no demonstrable metastases in the axilla. By radical mastectomy is meant sacrifice of both pectoral muscles with dissection of the axilla wide excision of the fascia and of the skin overlying the breast (Halsted or

Willy Meyer operations). In other words operative treatment should be as radical in the male as in the female. The prognosis in malignant diseases of the male breast is always guarded for as a rule these patients do not appear for treatment early. The possibility of a cure is directly proportional to the anatomic involvement by the tumor. Five year cures should be as good as in the female breast. When the disease has spread to the lymph bearing areas the prognosis is much more serious.

In view of the advancements in radiation therapy which have been made in the past decade today all malignant diseases of the male breast should have if possible preoperative and postoperative irradiation with x ray or radium.

Deaver and McFarland in their series estimate that 1.5 per cent of all malignant breast tumors and 2 per cent of all benign tumors occur in men and that 80 per cent of the tumors of the male breast are malignant. A total of 1.36 per cent of all the malignant breast tumors in patients admitted to the New York State Institute for the Study of Malignant Diseases were in men 44.4 per cent of these being malignant. In women 73 per cent of all the lesions were malignant.

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## **XXII. THE THORACIC WALL, PLEURA AND LUNGS**

### **PHYSIOLOGY, ANOMALIES AND TRAUMATIC EMPHYSEMA**

#### **THE MECHANICS OF RESPIRATION**

Success in surgery of the thorax is dependent on a high understanding of the mechanics of respiration and of the pathologic physiology of open and closed pneumothorax. While a knowledge of other aspects of respiratory physiology is important and in all will increase the surgeon's efficiency, it is absolutely essential for him to comprehend the mechanisms relating and to know how to handle and prevent untoward train of events which follow opening of a pleural cavity or mobilization of the thoracic

cavity. The fetus as a result of its position and the absence of muscular tone the thorax is so contracted that the cavity is no larger than the relaxed and airless lungs. At birth the straightening of the body and contraction of the muscles of respiration increase the size of the thorax. This increase is permitted and is gained by stretching of the lungs and aspiration into the bronchial and alveolar spaces. After the first breath the lungs are always stretched and always fully filled with air. This is the mechanism of the maintenance of the negative intrapleural pressure. It can be spoken of more accurately as the tension of the pleura to a pressure of 8 cm. of water) under which the lungs are stretched to fill the thorax and as being dependent on a disproportion between the capacity of the chest and the size of its contents. As the thorax expands on inspiration by contraction of the respiratory muscles the lungs are still further stretched and more air is drawn into them. On expiration as the thorax contracts they are permitted to draw in toward the chest and expel the air inhaled on the preceding inspiration. In other words the lungs passively follow movements of the expanding and contracting thorax and as they do so air is inhaled and exhaled. When an opening is made in the thoracic wall the thorax contracts and air is sucked into the pleural cavity. The lung on the affected side draws away from the thoracic wall and the one on the opposite side is pulled toward the midline. On inspiration as the thorax increases in size, more air is drawn into the pleural cavity, and the mediastinum follows the movement of the thoracic wall and shifts further over. On expiration as the thorax decreases in size, air is forced out of the pleural cavity and the mediastinum is pulled back toward the midline. A wound through which air thus enters and leaves the thorax on respiration is called a sucking wound and the to and fro movement of the mediastinum is called mediastinal flutter. It is obvious that this movement of air in and out of the wound is similar to breathing but that it is a useless interchange because the air merely enters and out of the pleural cavity and does not come in contact with any oxygen absorbing surface.

The subject is thus breathing both through the normal air passages and through the hole in the thoracic wall. The larger the hole, the more air goes in and out of it and the less goes in and out of the nose and mouth. If the opening is small (smaller than that of the glottis), normal respiration will usually be sufficient to support life but if it is large asphyxia and death will ensue. This is the mechanism of open pneumothorax.

There are certain pathologic conditions which prevent the untoward effects of open pneumothorax and certain ways in which they can be prevented artificially. Adhesions between the lung and the thoracic wall prevent collapse of the lung and movement of the mediastinum and since one lung functioning normally is ample to carry on respiration any infection that fixes the mediastinum and makes it rigid prevents "flutter" and permits efficient breathing. At operation if bad symptoms develop they can be stopped by grasping the lung and drawing it into the opening in the thoracic wall. This partially closes the opening and also stabilizes the mediastinum. A sucking wound of the chest should be closed immediately by packing until the patient can be transported to the operating room.

#### **PRESSURE ANESTHESIA**

During a surgical operation involving wide opening of the pleural cavity collapse of the lungs may be prevented by raising the pressure within them. This can be accomplished most simply with the ordinary apparatus and mask used for gas anesthesia. Many of the devices now on the market are so constructed that the pressure under which the gas is administered can be controlled and varied. If a device with these improvements is not available the older type may be adapted by connecting the exhalation outlet by means of rubber piping with a glass tube which can be lowered into a bottle of water to any desired depth. A resistance of from 3 to 5 cm. of water is ample. During the operation the distention of the lung can be controlled by raising or lowering the glass tube. A pressure much above 8 cm. of water should be avoided as there is some danger of rupturing the lung.

#### **ANOMALIES OF THE THORAX**

Anomalies of the thorax and its contents are numerous. The more serious anomalies are not compatible with life, and few of those that permit life interfere with function to such an extent as to warrant attempts at correction. Congenital elevation of the scapulae is not uncommon. One or both pectoral muscles on one or both sides may be absent. The sternum may be separated into two parts by a vertical cleft or may be deeply depressed toward the spine. Torking of a rib anteriorly is common as is also fusion of

two ribs There may be an extra rib in either the cervical or the lumbar region or the first or twelfth rib may be absent or rudimentary The whole or a part of other ribs may be missing

Anomalies of the lungs range from complete absence or hypoplasia of a lobe one lung or both lungs to the presence of supernumerary lobes These variations are of considerable importance in the localization of parenchymal bronchial or interlobar disease

The congenital anomalies which are of surgical importance are cervical rib pectus excavatum and congenital hernia of the lung Cervical rib congenital thoracic tumors and bronchial anomalies will be discussed in another section

**Pectus Excavatum (Trichterbrust Funnel Breast)**—*Definition*—A deformity of the thorax usually congenital but occasionally traumatic in which the sternum is depressed toward the spine sometimes to such an extent that symptoms are produced from compression of the heart

*History*—The first known description of the condition was given by Johann Schenck in the sixteenth century Wilhelm Ebstein in 1882 reported five cases described the symptoms and first used the term trichterbrust Ludwig Meyer in 1911 was the first to attempt to correct the deformity surgically James Carr reviewed the literature in 1933

*Deformity*—The condition occurs commonly in persons of an asthenic habitus The depression starts at the manubriosternal articulation and increases steadily to the xiphoid which is frequently depressed to within a few centimeters of the spine The transverse diameter of the chest and the anteroposterior diameters in the midclavicular lines are increased The cartilages sink abruptly backward to the depressed sternum

The heart is usually displaced to the left and rotated on its axis but occasionally it remains held in a normal position A depression on the anterior surface of the right auricle from the sternum has been noted

*Symptoms*—Usually there are no symptoms referable to the condition This is especially true if the heart has escaped well to the left When symptoms are present they vary from mild intolerance of severe exercise to marked dyspnea palpitation tachy-

cardia and precordial pain In the case reported by Carr and in which the writer operated there were recurrent attacks of unconsciousness

*Treatment* is surgical and consists in resection of the portions of the sternum and cartilages which are pressing on the heart This usually includes the lower half of the corpus sterni and the cartilages attached to it Operation should be resorted to only if the symptoms are handicapping and if they can definitely be attributed to the deformity

### TRAUMATIC EMPHYSEMA

Injury of any part of the respiratory or gastrointestinal tract may permit the escape of air into the tissues In the respiratory tract especially in the lung such a wound has a tendency to become valvular permitting the escape of air during one phase of respiration or on strong respiratory efforts and closing during the other phase to prevent its return In this manner, air is pumped forcibly to all parts of the body until the patient becomes seriously inflated

The condition occurs most commonly after a penetrating crushing or contusing injury of the thorax The fracture of ribs is not necessary The lung may be torn by the severe expiratory efforts of coughing or the straining incident to childbirth High pressure gas anesthesia or explosion of an anesthetic administered by the closed method may produce it The trachea or bronchi may be injured by foreign bodies or during bronchoscopy

An interesting group of cases follow tonsillectomy extraction of teeth and other operative or accidental wounds of the mucous membranes of the mouth nose and throat.

Generalized traumatic emphysema secondary to injury of the lung may disseminate by one of two routes If the lung is torn on its surface tension pneumothorax may force air through a wound of the parietal pleura into the tissues of the thoracic wall and thence over the whole body If the injury to the lung is internal the air is forced along the peribronchial and perivascular tissues to the mediastinum whence it travels upward to appear first in the supraclavicular fossae and downward retroperitoneally to appear in the groin

JEROME R. HEAD

## INFLAMMATIONS OF THE CHEST WALL, ETC

### INFLAMMATIONS OF THE CHEST WALL

**A Subpectoral Abscess**—A subpectoral abscess is an uncommon although serious lesion and because of its location beneath heavy bellied muscles it is frequently misdiagnosed in its early development. The infection begins in the subclavicular glands at the extreme apex of the axilla and is usually caused by a hemolytic streptococcus secondary to an infection or injury of the hand arm axilla or breast. It also may follow an injury of the chest wall or of the supraclavicular fossa.

The subclavicular glands lie adjacent to the axillary vein high in the axilla and just beneath the costocoracoid membrane. When the infection extends outside of these glands it spreads downward and outward beneath this fascia and at times may extend posteriorly around the chest wall to the subscapular region.

**Symptoms**—Since the infection lies deeply hidden from the surface local symptoms and findings are insignificant in the early stage and are usually preceded by fever chills and general malaise. Pain in the shoulder and arm especially on adduction or rotation rigidity of the pectoralis major muscle and a sensation of tenderness or pain near the middle of the clavicle are the first local manifestations. Examination reveals no early local abnormalities but later swelling and a fullness near the outer inferior border of the pectoral muscle with tenderness over this area are noted. Much of the swelling may be due to edema and the lack of fluctuation is misleading often delaying the diagnosis.

**Treatment**—Treatment consists of incision and adequate drainage along the outer inferior margin of the pectoralis major muscle. Additional drainage by division of the muscle fibers beneath the clavicle may be necessary. Owing to the location of the abscess pyemia and septicemia are not uncommon. The condition is always serious and the prognosis must be guarded.

**B Subscapular Abscess**—A subscapular abscess is much less common than a subpectoral abscess and usually produces few local or systemic symptoms. Although caused

by pyogenic organisms it may present the appearance of a cold abscess. At times it is differentiated from tumors only by the presence of fluctuation. Treatment consists of adequate drainage after determination of the etiologic organism by aspiration.

**C Acute Osteomyelitis**—Acute osteomyelitis of a rib may result from drainage of an empyema from trauma or from general staphylococcal infections. With the exception of the last mentioned the systemic involvement is much less common than that produced by infection in other bones. Involvement of the cut end of the ribs following rib resection for draining an empyema is not uncommon and produces no systemic reaction. Care must be taken that the sequestered end does not cause a chronic empyema by falling into the cavity and acting as a foreign body. Occasionally an entire rib may become involved and sequestrate. Surgical removal of the sequestrum is followed by complete healing. Osteomyelitis following trauma to a rib produces no special problem and is treated in the usual manner for this lesion. Osteomyelitis of the sternum is much less common but when present carries a high mortality.

Typhoid osteomyelitis of a rib is rarely seen since the incidence of typhoid fever has been reduced. The local condition may not appear for months or years after an attack of typhoid fever however a history of an attack is usually present. Locally a fluctuant swelling develops but signs of an acute inflammation are lacking. Its recognition is important in order to prevent spread of the organisms before the diagnosis is made. Typhoid osteomyelitis must be differentiated from tuberculosis syphilis sarcoma and chronic pyogenic infections of the rib. Aspiration and culture along with a history of typhoid fever are usually sufficient for establishing the diagnosis. Treatment consists of surgical excision of the involved bone.

**D Tuberculosis**—Tuberculosis of the sternum ribs and cartilages is a common lesion. It may develop by one of two methods either by direct extension from tuberculous glands lying just outside the parietal pleura usually near the sternum or by hematogenous spread from an active tuberculous lesion elsewhere in the body. The



former route is probably much more common since in many cases the tuberculous infection is around the rib or cartilage with no evidence of infection found within these structures.

Although this infection may occur at any age it is more common during middle life. The lesion presents local manifestations similar to those produced by cold abscesses elsewhere. There is little evidence of local inflammation, a fluctuant non tender swelling indicating its presence. If it is allowed to progress necrosis of the skin occurs with sinus formation. The infection may however extend quite some distance along a rib or cartilage before sinuses develop. Aspiration of the swelling reveals thick curdy pus. If a sinus is present injection of a radio-opaque material and a ray examination of the chest will aid in determining the limits of the involvement.

**Treatment**—Treatment consists of wide surgical excision of the involved rib or of the entire cartilage if the latter is involved. When no sinuses or secondary infection is present closure of the wound without drainage is indicated. Supportive treatment as for tuberculosis elsewhere is helpful.

**E. Actinomycosis**—Actinomycosis of the chest wall is practically always secondary to actinomycosis of the lung or intestine. In the former case the process extends outward through the pleural cavity and in the latter, extension is up through the diaphragm. Since this infection respects no tissue boundaries it involves all structures of the chest wall and slowly produces a brawny induration in the soft tissues with considerable swelling and edema. A productive cough usually with hemoptysis and local pain and tenderness are experienced along with constitutional symptoms of fever, weakness, sweats, anorexia and loss of weight. If the disease process is allowed to continue discharging sinuses are produced.

This condition may be mistaken for tuberculosis of the chest wall or tumor of the lung with secondary invasion of the chest wall. The diagnosis is established by the finding of sulfur granules in the exudate and the ray fungus on staining material removed by aspiration or biopsy.

**Treatment**—Treatment consists of wide excision of the involved parts usually per-

formed best in several stages. The use of thymol and potassium iodide by mouth and thymol locally has been of definite benefit in some cases. Local x-ray treatment may also be helpful. The prognosis is poor. Response to therapy is usually only temporary, the disease often recurring after a seemingly permanent cure has been effected.

### HERNIA OF THE LUNG

This is a very uncommon condition, only 171 cases having been reported in the literature up to 1933. The condition may be congenital or may develop following trauma to the chest wall. The congenital type is a true hernia with a sac of parietal pleura into which the lung protrudes and occurs most commonly near the sternum or vertebrae through an intercostal space. The acquired type may follow an injury to any part of the chest wall, the lung prolapsing through a defect produced by the trauma.

The usual symptoms are a bulging mass pain over the local area and cough. The size of the mass increases on coughing or straining. The cough is usually non-productive but may produce bloody sputum. Incarceration and strangulation of these hernias have been reported.

Physical examination reveals a soft crepitant bulging mass which suddenly increases in size on coughing. A bony or fibrous rim may be felt through which a finger may be inserted into the chest cavity. The diagnosis is easily made.

Since these hernias rarely heal spontaneously, treatment consists of freeing the contents of the hernial sac and closure of the defect in the chest wall by a plastic operation.

### TUMORS

Various tumors of connective tissue origin such as lipoma, lymphangioma, hemangioma, osteoma and chondroma may develop in the chest wall. The most common is chondroma or osteochondroma which arises from a rib cartilage or the sternum. Many of these tumors are malignant, especially those of a cartilaginous nature. Owing to the fact that most of them grow toward the pleural cavity, they may reach a considerable size before producing symptoms or before their presence is discovered. The tumor frequently

arises at a costochondral junction and owing to its slow growth symptoms may be entirely lacking until adjacent structures are influenced by pressure. All structures of the chest wall are usually involved by the growth which is more or less spherical in shape, hard and nodular with areas of softening due to degeneration. Since metastases are late the tumor is apt to be considered benign and differentiation is frequently difficult or impossible even on microscopic examination. Of 213 cases analyzed by Hed-

the tumor it can usually be filled in by the breast or scapula. Good results may be expected in the case of a benign lesion but recurrence is the rule following extirpation of a sarcomatous tumor.

A common malignant tumor described by Pancoast arises in the superior pulmonary sulcus. Although the source of development is questioned it is epithelial in nature and is likely bronchogenic in origin. This tumor gives rise to a characteristic clinical picture of pain in the shoulder, wasting of the mus-

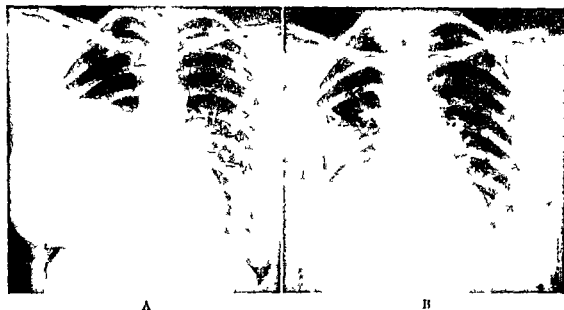


Fig. 11—A 35-year-old white woman entered the clinic complaining of some pain of several years duration beneath the right breast. There was slight dyspnea on exertion. On examination positive findings were limited to the right thorax which presented a large firm apical tumor beneath the right breast extending from the second to the sixth rib. Roentgenograms of the chest revealed a spherical opacity occupying the lower two-thirds of the right lung field. The tumor arose from the right fifth rib at its costochondral junction. It was removed en masse through a long incision over the entire length of the right fifth rib. Long segments of the fourth, fifth and sixth ribs together with the intercostal structures and parietal pleura were removed with the tumor. The defect left in the chest wall was closed by filling in with the scapula posteriorly and the right breast anteriorly. The patient made an uneventful convalescence and in seven years has had no evidence of recurrence. Microscopic sections revealed the tumor to be a chondroma.

blom (14 per cent) were sarcomas. In the absence of metastases differentiation between the benign and the malignant tumor is impossible before operation. They may also be confused with a dermoid cyst, cold abscess, aneurysm and exostosis.

Treatment consists in wide surgical excision. When the tumor is large no attempt should be made to preserve the underlying parietal pleura. Partial pressure anesthesia must be used for dealing with the surgical pneumothorax produced. If a large defect in the chest wall remains following removal of

cles of the hand and Horner's syndrome. Roentgenograms reveal a sharply defined opacity in the extreme apex of the plural cavity with destruction of one or more of the first three ribs and at times the adjacent vertebrae. There is no known effective therapy.

Other malignant tumors frequently seen in the ribs are metastatic carcinoma from the breast and multiple myelomas. The latter are more easily detected here than in other bones.

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## WOUNDS OF THE THORACIC WALL, PLEURAL CAVITY, LUNGS AND MEDIASTINUM

**General Consideration**—The functioning of the cardiorespiratory mechanism is dependent upon certain anatomical and physiological facts that must be understood in order to evaluate the seriousness of various types of thoracic wounds and at the same time to make an accurate appraisal of the individual patient. For anatomical and physiological details reference must be made to standard textbooks on these subjects.

From an anatomical standpoint primary consideration must be given to the large number of thin walled arteries and veins that are present not only in the mediastinum and lungs but in the chest wall as well. Attention must be directed to the difference in pressure in the two arterial systems the peripheral and the pulmonary.

The method of arresting hemorrhage in thoracic wounds differs with the type of blood vessel injured. If for instance a laceration of the lung causes hemorrhage from the pulmonary system owing to the low pressure in the pulmonary vessels resulting in the escape of blood into the thoracic cavity or hemothorax the bleeding can be arrested by compression of the lung whereas in an injury to the heart aorta or subclavian internal mammary or intercostal arteries hemorrhage into the pleural cavity or hemothorax may occur that will not subside following compression of the lung. Because the pressure in the systemic arterial system is high compared to that in the pulmonary system bleeding from the systemic arterial vessels will be much more vigorous than that from the pulmonary vessels. In case ligation of the pulmonary artery is necessary because of hemorrhage from the lung due to penetrating or perforating wounds it is well to know that the bronchial artery will supply a sufficient amount of arterial blood to prevent the lung from becoming necrotic or gangrenous. It must be noted that the pulmonary artery carries mainly venous

blood with a relatively low oxygen tension whereas the reverse is true of the bronchial artery. Cutting-off of the flow of blood from the pulmonary arterial system will therefore not affect the lung from a nutritional standpoint but of course will prevent its functioning from the standpoint of oxygenation of the blood brought to the lung. Circulation in the lung after ligation of the pulmonary artery is switched from an essentially venous circulation of relatively low oxygen tension to an arterial circulation with high oxygen tension. The development of the collateral circulation through the bronchial artery is rapid and extensive following ligation of the pulmonary artery.

Bleeding from venous structures that may be injured in wounds of the thorax must also be taken into consideration. These are the superior and inferior vena cavae and the innominate axillary and hemiazygos intercostal and subclavian veins which may be considered the peripheral venous system. The arrest of hemorrhage from them presents a different problem from the control of bleeding from the pulmonary veins. Because of the vestigial character of the bronchial veins the blood must be carried away from the lung by way of the superior and inferior pulmonary veins. Therefore ligation of either of these will result in most gangrene in the area of the lung which is drained by the ligated vein. If either the superior or the inferior pulmonary vein must be ligated because of injury it will be necessary to remove that part of the lung drained by that particular vein. This dual circulation of the lung must be borne in mind in the treatment of wounds of this organ.

Destruction or displacement of certain anatomical structures by injury interferes with the proper physiological function of the intrathoracic organs. The rigidity of the thoracic cage which is due to the anatomical integrity of the ribs and sternum is essential to the proper filling of the lungs during inspiration. This rigidity affords a purchase for the pull of the diaphragm and the intercostal muscles as well as the accessory muscles of respiration and maintains negative pressure within the thoracic or pleural cavity and as well within the air passages of the lung. Any interference with this rigidity permits collapse of the chest wall during inspiration owing to the contraction of the diaphragm. In addition to rigidity the thoracic wall must be intact for obviously a defect in the chest wall from an injury even though the rigidity in general is maintained allows the passage of air into the thoracic cavity and interferes with the proper filling of the lung because of loss of the normally present negative intrapleural pressure.

When air accumulates in the thoracic cavity there develops what is known as pneumothorax resulting in compression of the lung on the ipsilateral side and sometimes on the contralateral side. In addition to the direct effects of the loss of the negative intrapleural pressure on the filling of the lung with air there are other results of this loss which affect the normal physiological activity of the heart and therefore the cardiac output and blood circulation in general. The action of the thorax during inspiration with its effect on the filling of the right atrium is profoundly interfered with when there is disturbance of the delicate pressure balance within the pleural cavity. Serious effects

upon the general peripheral circulation may result therefrom. In dealing with perforating or penetrating wounds of the thoracic cavity one must bear in mind the intimate relations between the anatomical and the physiologic aspects of the problem. Although general surgical principles are applied in the treatment of such wounds of the regard must be given to certain special aspects of thoracic wounds that set them apart from wounds of the head, abdomen and extremities.

Infection carried in to the pleural cavity from the outside and entering from within by way of the bronchi or the esophagus will be discussed under the various types of wounds.

In view of experience not only in civil practice but that which was reported from World War I and has been gained up to the present time in World War II it has been thought wise to consider the treatment of wounds of the thorax under the following headings: 1 *non penetrating wounds*; 2 *penetrating wounds*; 3 *perforating wounds*; 4 *combined pleuroabdominal wounds*; and 5 *concussion of lungs from blast injuries*.

Before discussion of these various injuries in detail it is well to note that there are certain fundamental principles pertaining to the treatment of thoracic injuries which must be observed in order to obtain the best results. In addition to the general surgical principles that are applied to the treatment of wounds elsewhere in the body, there are certain first aid measures that are essential if thoracic wounds are to be successfully treated. These measures are the arrest of hemorrhage from the thoracic wall, correction of disturbance of the cardiorespiratory physiology and prevention of infection. The arrest of hemorrhage from the thoracic wall is carried out according to well known general surgical principles. A sucking wound of the chest, the so-called sucking pneumothorax, which is due to a defect or an opening in the thoracic wall requires an immediate airtight dressing and subsequent closure of the wound. So-called pressure pneumothorax or accumulations of air under pressure in the thoracic cavity must be provided with means of escape; this is accomplished by the use of a trap valve, a mechanism which allows air to escape but not to enter. Crushing injuries to the chest wall due to multiple fractures of the ribs or sternum associated with paradoxical respirations demand immediate external stabilization of the thoracic wall. This can usually

be accomplished by non operative methods such as strapping or external traction. Hemothorax or hemorrhage into the pleural cavity must be treated by aspiration with replacement by air or the establishment of an artificial pneumothorax. Hemorrhage which progresses in spite of collapse of the lung makes exploratory thoriotomy mandatory. Hemotamponade from hemorrhage into the pericardium resulting from wounds of the heart or large vessels within the pericardial sac should be relieved by aspiration until the nature of the wound is determined and facilities are obtained from exploration of the pericardium and heart.

Because of limitation of space the general surgical measures employed for the treatment of all injuries such as debridement, chemotherapy, treatment of shock and administration of tetanus antitoxin and toxoid are purposely omitted from this discussion.

**1 Non Penetrating Wounds of the Thorax**—A wound which involves only the chest wall without opening the pleural cavity is termed a non penetrating thoracic wound. Such wounds are usually not associated with symptoms and signs referable to the pleural cavity or the cardiorespiratory system. There is unlikely to be hemoptysis, pleural effusion, hemothorax or disturbance of respiration. There may be some splinting of the side owing to local pain during the respiratory cycle. As a rule the management of such superficial wounds depends upon the cause. In a simple stab wound or bullet wound the treatment is conservative. If the wound is caused by a high explosive fragment it seems advisable to excise the wound. It should be remembered that such wounds of the posterior thoracic wall are more apt to result in deep infection than are those of the anterior wall. This fact is probably due to the greater likelihood that hematoma will be formed in the deep muscular layers posteriorly rather than anteriorly and will subsequently become infected. In some instances hemoptysis is present when the pleural cavity has not been perforated. This may be due to intrapulmonary hemorrhage as a result of concussion from non penetrating blows on the chest wall as seen in automobile accidents or as a result of simple fracture of one or more ribs from a fall in which the ribs have penetrated the

wound to a large defect in the thoracic wall as the result of a high explosive missile. The signs and symptoms of course vary in direct proportion to the extent of the injury. In a simple stab wound or gunshot wound which punctures the pleural cavity but does not cause serious hemorrhage and shock only some local pain the patient may even be unaware of the presence of the wound. Such simple penetrating injuries are practically asymptomatic and treatment is always conservative unless a foreign body is found in the thoracic cavity as a result of roentgenographic study. In such a case one should always suspect that other foreign bodies may have been carried into the pleural cavity with the penetrating fragment such as portions of the clothing. It is probably wise to excise the wound of entrance perform a thoracotomy remove all foreign bodies close the wound and observe the patient for possible infection.

If however the penetrating injury severs a peripheral artery such as an intercostal the internal mammary or the subclavian artery or on the other hand one of the major pulmonary vessels near the hilum or the azygos vein associated with the injury there will be bleeding into the pleural cavity resulting in hemothorax and attended by a certain degree of shock. The bleeding will be slow or brisk depending on the size of the injured vessel. If however an intercostal vessel is severed without laceration of the lung hemothorax may be present without expectoration of blood. The hemothorax will progress but not so rapidly as it will from an injury to the internal mammary or subclavian artery. Often the wound of entrance gives a clue to the possible source of the bleeding. In the case of injury of the internal mammary artery the anatomical location of the entrance wound is about 1 cm lateral to the sternal border. A bleeding wound in this region at once suggests injury to this vessel particularly if there is hemothorax without hemoptysis. Again a wound of entrance near the dome of the chest in the region of the subclavian vessel suggests the possibility of a hemothorax originating from this wound. More frequently however there is associated with such penetrating injuries a concomitant laceration of the lung from which there arises

bleeding in the pleural cavity and in the alveoli resulting not only in hemoptysis but also in hemothorax from the lacerated lung as well as from the peripheral vessels. In other words there is bleeding from both the pulmonary and the peripheral arterial system. In most instances however only a laceration of the lung results from a penetrating injury. Furthermore lacerations of the lung differ in extent. A peripheral laceration bleeds less rapidly and vigorously than does a laceration of the hilum. Again the wound of entrance and the probable course of the penetrating body aid in determining the severity and nature of the intrathoracic wound.

In all of these cases treatment consists of first aid for shock with administration of blood or plasma as well as administration of morphine and the patient must be placed under close observation. No set rule can be given for the definitive treatment.

Small penetrating wounds such as bullet wounds which do not admit air are usually treated conservatively particularly if there is reason to believe that only laceration of the lung has occurred. If however because of recurring hemoptysis in the presence of artificially produced pneumothorax there is reason to believe that the bleeding persists in spite of the collapse of the lung thoracotomy should be performed immediately search made for the bleeding vessel and ligation carried out. As mentioned previously hemothorax that persists and recurs after repeated thoracenteses and after the injection of air has produced collapse of the lung must be regarded as arising not from the pulmonary circulation but from the peripheral circulation, and unless the bleeding is arrested the patient will bleed to death within his own pleural cavity. If in addition the penetrating wound has produced a large defect in the thoracic wall the diameter of which is larger than that of the trachea there results a sucking pneumothorax which necessitates immediate air tight closure. The larger the defect the more urgent the necessity for preventing aspiration of air. The sequelae of such a sucking pneumothorax have been discussed. The patient should be treated immediately for shock in the usual manner with mild sedation such as a small dose of morphine. The

opening in the chest wall should be closed immediately as an emergency measure with any dressing that is at hand such as adhesive type or petrolatum gauze. If the wound is extensive such as those made by irregular fragments careful debridement of the skin and muscles must be done. The thoracic cavity should be cleaned out thoroughly and all foreign bodies removed. If laceration of the lung is present this should be repaired either by direct stitching or by transfixing the lacerated edges. In some instances it may be necessary to perform lobectomy; however this procedure should be reserved for the most serious tears and lacerations. It should be carried out under general anesthesia with intratracheal insufflation or a very tight fitting mask so that differential pressure may be maintained. Closure of the defect in the thoracic wall is essential and can be accomplished by the use of pedicle flaps of muscle from the pectoral group or the latissimus dorsi and also by crushing the phrenic nerve (either in the neck or trans thoracically) from the immobilized diaphragm. Occasionally it is advisable to stitch the damaged lobe of the lung into the defect so as to fill the opening into the pleural cavity. In some cases it is possible to cover the defect with skin. Drainage by water seal catheter should be instituted and the patient should be carefully observed for the development of empyema. It is advisable to administer oxygen as soon as possible.

It is well to remember that one or all of the combinations of injuries to the various organs occur with penetrating wounds. In all probability each case will be different and must be considered individually. Sometimes pressure pneumothorax develops from a penetrating injury that produces laceration of the lung or from injury to one of the primary bronchi or the trachea. Because of the absence of an avenue of escape the intrapleural pressure increases to the point where labored respirations and greater dyspnea are produced with dislocation of the mediastinal contents towards the uninjured side. The thoracic cavity on the uninjured side should be punctured in the second interspace anteriorly with a 15 or 20 gauge needle which may be attached either to a water seal catheter or to a perforated finger cot so that air may escape from the pleural

cavity but cannot be sucked back into it. If this method of treatment is insufficient to overcome the increased pressure either thoracotomy with closure of the defect in the trachea or bronchus and stitching of the lacerated lung or lobectomy is advisable. If the defect in the bronchus or the trachea is of sufficient size to prevent closure of the wound by suturing a small patch of parietal pleura can be sutured as a transplant or pedicle flap across the defect.

If injury to the esophagus is present this structure should be repaired by direct suture. It is usually possible to mobilize the esophagus sufficiently to bring the lips of the defect together. Suture of the esophagus should be done with interrupted silk sutures in the mucosa which is the most useful layer available for sewing. The muscular layers should then be brought over the mucosal sutures. The mediastinal pleura in that region should be allowed to remain open so that if there is infection it will drain into the pleural cavity. After the proper use of chemotherapy the thorax should be drained by means of a water sealed catheter.

Injuries of the esophagus or the trachea are usually associated with mediastinal emphysema which can be detected primarily by crepitation in the suprasternal notch. If the course of the penetrating missile seems to demand it the esophagus should be explored.

In thoracic injuries it is preferable to explore the esophagus through the thorax rather than through the posterior mediastinum for this approach enables the operator not only to explore the thoracic cavity but to examine the lung and adjacent structures as well.

Penetrating injuries associated with wounds of the heart may occur with or without communication between the pericardial and pleural cavities. If there is no communication there is usually massive intrapleural hemorrhage and the patient rarely survives long enough to be hospitalized. However in case operation is resorted to the approach should be transthoracic with aspiration of blood from the chest and pericardial cavity and an attempt should be made to suture the wound in the heart or the great vessels emerging from the heart.

In case of injury to the heart in which

there is no communication between the pericardial and pleural cavities bleeding into the pericardial sac results in pressure upon the heart or cardiac tamponade. This is clinically manifested by peripheral circulatory collapse distended veins of the neck with great increase in venous pressure small pulse pressure muffled heart sounds and an immobile cardiac shadow on fluoroscopic examination. The pericardial sac should be aspirated by the costophrenoid route and if the tamponade persists or recurs after several aspirations the heart should be exposed extrapleurally and cardiorrhaphy or suturing of the wound of the heart performed.

### 3 Perforating Injuries of the Thorax

—Perforating injuries of the thorax are those in which the foreign body has completely traversed the thorax causing a wound of entrance and a wound of exit. The patient is usually very little disturbed from the clinical standpoint. After treatment for shock and the usual rehabilitation therapeutic procedures such as sedation and rest the patient should be examined by x-ray if the roentgenogram reveals retained foreign particles within the lung or thoracic cavity these should be removed. In other respects perforating injuries of the thorax are treated in the same manner as penetrating wounds.

### 4 Pleuroabdominal Wounds—Trans

diaphragmatic injuries or rupture of the diaphragm are as a rule the result of a crushing injury to the chest or abdomen or both. There are severe epigastric pains a persistent hyperresonant percussion note at the left base and distant and diminished breath sounds. The posterior portion of the left side of the diaphragm is usually injured and a diagnosis of such an injury can be made in almost every instance roentgenographically. Various portions of the abdominal viscera may have ascended into the thoracic cavity. Rupture of the right side of the diaphragm is more uncommon than that of the left but in the event that this has occurred a portion of the right lobe of the liver may be found in the thoracic cavity. A combined thoracoabdominal incision should be made in the ninth interspace with exposure of the upper right or left quadrant depending upon the individual case. General anesthesia must be used with differential pressure maintained by tracheal insufflation or a tight

mask. Injuries of the abdominal viscera or lung are treated according to their type. The diaphragm is sutured after the abdominal viscera have been returned to the peritoneal cavity.

**5 Concussion of the Lung**—Concussion of the lung following blast injuries or impacts by pressure waves from high explosives at close range sometimes causes extensive damage to the lung without evidence of external injury. Such an injury is associated with profound shock cough hemoptysis of varying degree dyspnea and cyanosis. Roentgenographic study of the chest may not be helpful for the first few days after the injury. Autopsies in Britain during the period of the heavy bombing of London showed the lesion to be an intrapulmonary hemorrhage varying from petechiae to large ecchymotic areas.

Treatment includes rest administration of oxygen and sedation. If concurrent injuries to the body necessitate the use of anesthesia local intravenous or spinal anesthesia should be employed rather than an inhalation type.

WILLIAM F. RICHMOND, JR.

## SURGERY OF THE PLEURA

**Anatomy**—The parietal pleura is separated from the chest wall by the endothoracic fascia. The normal pleura is so thin that the most delicate dissection is necessary to avuls it. It often tears spontaneously after being detached from the endothoracic fascia. It is so frail that it is useless to try to suture it since the stitches tear through. The costal portion of the pleura is loosely attached to the chest wall except at the apex where lesser strands fix it to the prevertebral fascia. The mediastinal pleura is also loosely attached but all of the visceral pleura is normally fastened to the underlying structures.

In the loose nests of the endothoracic fascia runs a rich network of lymph spaces. If drained into a series of intercostal glands. By injecting salt solution or a alkali solution of procaine into these meshes even though they may have been obliterated by inflammatory processes the pleura can be separated from the chest wall and protected from tearing during resection.

The topography of the pleura is apparent from the accompanying diagram. The lungs do not quite reach the edge of the pleural cavity; there is a reserve space at the bottom of the chest at which fairly broad surfaces of the diaphragmatic and the costal portions of the pleura are in contact. On inspiration this space, the complementary sinus, is widened; on expiration it is narrower but never not even on maximum inflation

does the lung quite fill it. Free pleural exudates naturally gravitate toward this sinus and force the pleural layers apart, subdiaphragmatic effusions and shrinking intrathoracic processes that lift the diaphragm bring the diaphragmatic and costal portion of the pleura into broader apposition, increasing the depth of the sinuses. Both the normal and the abnormal topography of the complementary sinuses are therefore of much importance in calculating the sites of proposed openings into the chest. It is also noteworthy that the pleural reflection is, at the bottom of the complementary sinus, does not quite reach the diaphragmatic insertion but that there is a small triangular area between the diaphragm and the chest wall filled with loose endothoracic fascia or with fat through which the diaphragm may be reached from above without traversing the pleura. By a properly placed incision therefore, one may gain access to the upper surface of the diaphragm lift up the pleural sac without entering it and even make a transdiaphragmatic laparotomy without opening the pleura. This procedure is more easily carried out when the pleura is thickened and inflamed than when it is normal.

risks regularly accompanies fracture of ribs, and the pain may last many weeks. The exudate is partly absorbed and partly organized, adhesions often form at the site of injury and occasionally, perhaps as the result of superimposed infections, the pleura thickens so that the chest wall is lined with a casing resembling a bacon rind. Local tenderness to pressure in the intercostal spaces, spasm and immobility of a portion of the chest wall, with dullness to percussion, diminution of breath sounds, a pleural friction rub and a more or less pronounced area of increased x-ray density, give evidence of such a pleurisy. Strapping a wide area of the hemothorax with elastic adhesive plaster and allowing the patient to lie on the affected side, a position which he naturally assumes will give relief. If pain persists, blistering or

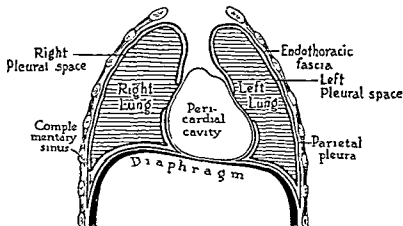


Fig. 472.—Topography of the pleura and complementary sinuses (Redrawn after Corning)

The topography of the visceral portion of the pleura also merits detailed study, for while the visceral covering of the pulmonary surface is comparatively simple, the interlobar fissures into which the pleura dips present complicated relations. Collections of fluid encapsulated between the layers of the interlobar pleura may give rise to roentgenographic shadows that are difficult to interpret.<sup>1</sup>

**Physiology.**—(See section on Mechanics of Respiration.)

### INJURIES OF THE PLEURA

**Traumatic Pleurisy.**—Traumatic pleurisy is a common ailment. Blunt violence or contusion of the chest wall may set up a painful, localized pleurisy, often with a bloody fibrinous deposit. Coexistent syphilis may give rise to massive, bloody effusion out of all proportion to the inciting injury. Pleur-

is painting the chest with several coats of tincture of iodine are old-fashioned remedies that are often useful. The intercostal neuralgia or neuritis may be severe and obstinate enough to call for posterior rhizotomy.

**Injuries of the Pleura.**—(See sections on Traumatic Emphysema, Pneumothorax and Hemothorax.)

**Pneumothorax.**—(See sections on Pneumothorax.)

**Hemothorax.**—(See section on Hemothorax.)

**Hydrothorax.**—*Serous effusion* into the chest, whether a dropsical transudate of low specific gravity (less than 1.015) or an inflammatory exudate of higher specific gravity, may be tapped if necessary but should not be treated by open drainage. The incal-



culable harm that results from this ill advised procedure makes it seem wise to sound this warning in a surgical text

**Chylothorax**—Chylothorax results from intrathoracic injuries to the thoracic duct or from disease causing damage to the duct Leaks in the lower part of the duct usually cause right sided chylothorax leaks in the upper part cause a left sided one Treatment is by aspiration

### INFLAMMATION OF THE PLEURA

Inflammatory disease of the pleura surgically considered is always secondary It may be dry and fibrinous (adhesive or obliterative pleurisy) as in the traumatic pleurisy just described serous (the usual tuberculous pleurisy) sanguinolent (tuberculous or carcinomatous pleurisy) or purulent (suppurative pleurisy empyema thoracis) The infectious agent may reach the pleura directly as in an infected penetrating wound or a ruptured lung abscess by continuity via the lymphatic channels from the most varied inflammatory disease of the neighboring structures as in acute pleurisy and empyema associated with pneumonia subdiaphragmatic abscesses osteomyelitis of the ribs and vertebral bodies etc and finally and rarely via the blood stream as part of the picture of pyemia Most cases of acute empyema encountered in civil life are metapneumonic or postpneumonic

### ACUTE SUPPURATIVE PLEURITIS (ACUTE EMPYEMA)

**Pathology**—An early acute inflammatory exudate is serous but may be more or less turbid it is usually odorless but in putrid infections it may be extremely foul while still quite clear it has a high specific gravity (more than 1.015) microscopically it contains polymorphonuclear leukocytes in various stages of development and degeneration and a small proportion of lymphocytes and endothelial cells it may or may not contain bacteria demonstrable by smear or culture Some pleuritic exudation regularly accompanies adjacent inflammatory disease The pleura itself seen in these early stages is thickened red inflamed and no longer glistening Later if the exudative pleurisy goes on to suppuration the exudate becomes more turbid opaque milky creamy or more

or less bloody Thick yellow pus is usually homogeneous the thinner less opaque effusions are often mixed with large flakes shreds and curds of coagulated fibrin Such pus contains large numbers of leukocytes with nuclear debris The pleura is thickened edematous and succulent and beset with shaggy tufts of fibrinous deposit Organisms are usually demonstrable in the pus by smear and culture streptococci and pneumococci are the most frequent offenders more rarely staphylococci and in fulminating putrid infection there is a mixed putrefactive flora Pneumococci predominate in empyema in children while streptococci are usually found in adults The epidemic empyemas following epidemics of measles in fluenza and epidemic bronchopneumonia are streptococcal Tuberculosis is strongly to be suspected if no organisms can be demonstrated in the pus In empyema the chest at times contains not only pus but air or gas which may come either from a perforating pulmonary suppuration communicating with the bronchial tree or from the presence of gas forming anaerobes

The exudate may lie free in the pleural space collecting in the dependent portions of the chest or if an adhesive pleurisy has preceded exudation the fluid may be confined by adhesions to certain characteristic locations Thus we speak of interlobar empyema when the pus lies confined in an interlobar fissure such an empyema owing to its proximity to the larger bronchi is usually liable to perforate into the lung A distal empyema lies confined medially between the lung and the mediastinum Diaphragmatic empyema lies between the lung and the diaphragm

**Symptoms and Course.**—The graphic chart of an ordinary postbronchopneumonic empyema has a characteristic appearance The pneumonic fever has abated the temperature pulse and respiratory rate and leukocyte count have dropped but not to normal After a week or so of a subfebrile course the temperature again rises and the patient begins to lose weight and strength he sweats he has difficulty in breathing and he has pain or a sense of oppression in the chest Expectoration diminishes but not the cough which is irritating and nonproductive The affected side lags or stands still on

respiration the intercostal spaces bulge especially in weakly children they are moderately tender to pressure over the lower parts of the chest. The heart and mediastinum are crowded toward the unaffected side. The lower part of the chest is solidly dull and the upper part somewhat hyperresonant over the flat area. Breath sounds are missing above it. Breathing may be tubular or vesicular and distant farther up there may be the loud sharp breathing of a compressed useless lung. Administration of sulfonamide drugs in pneumonia probably tends to prevent empyema but it also tends to mask its presence. Fever and the ordinary constitutional symptoms of toxicity may be wanting still the chest may be full of pus.



FIG. 473.—Roentgenogram of right-sided basal effusion.

**Diagnosis.**—An x-ray film which should be taken with the patient sitting or standing demonstrates a curved shadow obscuring the lower part of the chest; its outer portion running upward along the chest wall. It also corroborates the clinically manifest displacement of the heart and mediastinum. The film may show patches of bronchopneumonic consolidation here or there perhaps on the opposite side or what is more important evidence of recent or obsolete tuberculosis in the apices, a pericardial effusion or other complications which should be ascertained before treatment is begun. Films of a recumbent patient are almost valueless; the boundaries of a free effusion and disease of the underlying lung are indistinguishable in such a picture. If the patient

cannot sit up he should be placed first on one side then on the other and an anteroposterior roentgenogram should be made in each position so that the fluid may gravitate toward the lateral or medial side of the chest.

**b Aspiration (thoracentesis)** is necessary and helpful even though a roentgenogram is at hand. However it is not entirely harmless. The utmost care should be taken not to puncture the lung especially when the patient is coughing constantly for one may be sure that if the effusion is not purulent when the lung is punctured it will become so afterward. Simple puncture of the chest wall and pleura in such a case is not entirely harmless either the violent increase of intrathoracic pressure that accompanies severe fits of coughing may force infectious material from a virulently infected pleura into the loose spaces between the thoracic musculature giving rise to phlegmons more serious and difficult to deal with than the empyema for which puncture was done. For these reasons therefore it is wise to make provision for immediate drainage at the site of puncture if pus is found or else if operation is not contemplated or seems inappropriate to defer puncture.

It should be remembered that physical and roentgenologic signs of atelectasis may closely resemble those of an effusion. If the density does not shift with changes in the patient's position and if the mediastinal viscera are retracted toward the affected side aspiration should be undertaken if at all only with considerable misgiving and after due deliberation.

With these preliminary precautions and several well fitting glass syringes with a number of well fitting clean needles procaine solution, water culture tubes and containers are sterilized and after injection of a local anesthetic into the chest wall a No. 19 gauge 9 inch needle is slowly introduced into the pleura across the top of a rib at a site where local tenderness, bulging of the intercostal spaces and flatness indicate the presence of fluid. A small bore 10 to 15 cc syringe should be used for exploration; larger syringes impart the danger of sensation. As much pus as can be conveniently aspirated is removed, and cultures and smears are made.

Only if the smears demonstrate organisms and polymorphous white cells it is permissible to proceed with rib resection. The absence of organisms usually means that tuberculosis

sis is present and to treat a tuberculous empyema by open drainage is as Ciot said of other cold abscesses "to open the door whereby death enters" If the first exploration fails to demonstrate pus, puncture may be repeated elsewhere.

**Treatment.**—An acute empyema having been demonstrated the question of treatment arises. Decision is not always easy. Open rib resection and drainage are disastrous to a patient still suffering from severe pneumonia or its immediate toxic after effects. The mortality of early rib resection during the influenza epidemic of 1918 was from 40 to 90 per cent. Increased respiratory

tensor axillary line and the line of the scapular angle (provided exploratory puncture has demonstrated pus at this site of election). A large trocar and cannula are thrust into the chest through the scalpel puncture the trocar is withdrawn and a stiff rubber catheter (no 18 or 20 F) rapidly substituted for the trocar. The cannula is withdrawn leaving the catheter in the chest as an air tight drum. Before beginning operation one should make sure that the catheter fits the cannula the catheter should have two eyes about 1 inch apart it should be marked at the point which is to correspond to the skin level before it is inserted so that its openings be near or at the bottom of the chest. If it is pushed in too far it will not drain properly. Catheter drainage has the advantage of allowing the fluid to drain slowly and continuously under its own pressure and to be less liable to be plugged with blood or fibrin than a pump apparatus. The

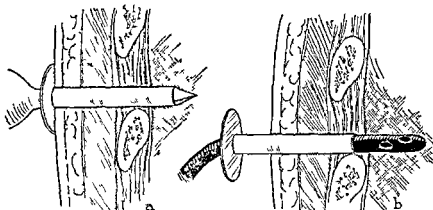


Fig 474.—Diagram showing introduction of the catheter into the pleural cavity in the closed method of treating empyema. a The trocar is passed through the thoracic wall. b The obturator of the trocar has been withdrawn and the catheter inserted through the trocar which is then being withdrawn.

difficulty and pain flapping about of the acutely pneumonic lung and increased absorption from the freshly opened pleural cavity all tend to contribute to the fatal outcome of early open operation. In an acutely toxic patient with high fever, cyanosis and distressing dyspnea the chest should be emptied of fluid either by aspiration or by intercostal siphon drainage.

If aspiration is decided on a large gauge needle is inserted into the chest and the fluid aspirated with a large glass syringe or pumped out with a vacuum bottle (Potam aspirator). Aspiration is repeated as the fluid reaccumulates usually every three or four days. Siphon drainage is probably better and is carried out as follows.

Under local anesthesia and with the patient propped up in bed in a sitting position a pointed scalpel is thrust into the skin and soft parts over the seventh or eighth intercostal space half way between the pos-

terior axillary line and the line of the scapular angle. The fluid of a virulent streptococcal empyema is usually turbid, thin and bloody and contains little fibrin at first, it usually runs out easily, later it becomes thicker and greenish and contains large curds of fibrin. At this stage the cavity may be irrigated with Dakin's solution which has the property of dissolving fibrin. If a sufficiently intelligent assistant is at hand the irrigation may be accomplished with a hand syringe if not one of the many apparatuses for tidal irrigations may be used. Occasionally in pneumococcal empyemas of children (18 per cent) more rarely in empyemas of adult age (11 to 13 per cent) aspiration or intercostal siphon drainage with irrigation is all

that is necessary to effect a cure. Ordinarily the exudate becomes less and less serous and thicker aspiration gives a scanty yield the cannula no longer fits securely pus leaks around it and the empyema becomes subacute. At this time the chest should be efficiently opened by resection of a rib. Sulfonamide drugs administered by mouth and used in solution to irrigate the empyema cavity may increase the percentage of cures by aspiration and closed drainage methods and may lessen the need for rib resection. Irrigations with sulfonamides produce high drug concentrations in the pleural fluid with little absorption into the blood stream absorption drops and local concentration rises as the empyema grows older and the pleura thickens. Recent reports indicate that penicillin is even more efficacious especially in staphylococcal empyema. Through an intercostal catheter 30 000 to 100 000 units should be instilled into the chest and allowed to remain for eight to twelve hours. After this the solution should be drained off and replaced by a fresh amount. The drug may be administered intramuscularly or intravenously at the same time.

*Rib resection and open drainage* are carried out as follows:

With the patient propped up in a sitting position the skin the soft parts and the intercostal spaces above and below the eighth rib in the posterior axillary line are infiltrated with novocain. The soft parts including the periosteum are incised over the rib the periosteum is detached and 1/2- or 2 inches of rib is resected. The underlying intercostal nerve is injected with 0.5 cc of absolute alcohol to prevent pain from the pressure of a drainage tube and the posterior costal periosteum with the subjacent pleura is incised. Large free curds of fibrin are removed by suction or with a sponge holder. Attempts to clean the pleura by rubbing it with gauze or otherwise maltreating it are purposeless. A large moderately soft rubber drain about 1 inch in diameter with one or two openings cut into one end and with a soft Penrose drain or a slit finger-cot tied over the other end to act as a valve is inserted for 2 or 3 inches into the chest and securely held in this position by sewing it to one edge of the skin with a loose stitch of silkworm gut. Loose iodoform gauze packing is inserted into the soft parts which are not sutured about the drain but left entirely open. Irrigation of the chest has but little purpose after rib resection for once the thorax is efficiently open it is impossible to reach all the pleural cavity with irrigating solutions. They merely puddle in the bottom of the chest and keep the patient wet and uncomfortable.

Drainage is means of a skin flap without the use

of tubes has proved especially useful in military hospitals and other situations where a minimum of after-care is possible. A U-shaped flap of skin and subcutis is turned up its base lying at the level of the rib which is to be resected. The rib is resected together with its periosteum the skin flap is tucked into the opening and its corners are attached to the pleura with two catgut sutures. The flap forms a valve through which it is easier for the contents of the chest to escape than it is for air to enter. A liberal dressing of petrolatum is left undisturbed for many days the outer dressings being changed as necessary. The empyema heals with a minimum of attention and without the irritation and discomfort of a rubber tube.

Theoretically it is hard to understand how an empyema cavity treated by rib resection with an opening in the chest wall the diameter of which exceeds the diameter of the glottis should ever heal. It would seem easier for the act of inspiration to suck air through this opening than through the glottis thereby causing a lesser pressure inside the lung than outside and maintaining the lung in a state of permanent collapse. Yet experience shows that this theory does not hold and that drained empyemas do heal. The fact is explained by the following considerations: (1) The wound is never perfectly open but is partially occluded by dressings which act as a valve making it easier for air to escape from the chest than enter into it. (2) Each rise in intrapulmonary pressure above atmospheric pressure especially coughing talking or any expiratory effort against a closed glottis forces air from the inflated lung into the collapsed one dilating it. (3) Unless bound down by some shrinking intrapulmonary disease the healthy lung tends inexorably to expand adhering a little further to the chest wall until it finally fills the whole thoracic cage.

It is quite possible that recent experiences in military hospitals may revolutionize the treatment of acute empyema especially of the traumatic variety following infected hemothorax. The methods under trial include liberal transfusion of whole blood and plasma use of penicillin locally and intravenously wide thoracotomy under intratracheal anesthesia decortication (stripping of inflammatory products from the visceral pleura) immediate insufflation and reexpansion of the lung and closure of the chest with a tight intercostal drainage. Drainage is used merely to take care of post-operative effusion the drainage tubes are withdrawn in a few days.

**Varieties of Acute Empyema**—It remains to discuss some varieties of acute empyema which from their course or localization present certain peculiarities. Epidemic empyemas seem to have certain characteristics that remain constant in each epidemic but vary from one epidemic to another. Thus the empyemas of the 1917-18 war-camp epidemic of influenza and upper respiratory infection were characterized by extreme prostration deep cyanosis and dyspnea high fever and high pulse and respiratory rates.

The effusions were large and consisted at first of a thin turbid serous effusion often with a putrid odor which was especially pronounced in the empyema following measles pneumonia.

This type of empyema appeared early in the course of a sudden diffuse patchy bronchopneumonia although the patients frequently told of an ambulatory respiratory infection a cold with some fever and malaise lasting about two weeks to which they had given little attention. Massive effusion became apparent early three to five days after the onset of pneumonia while the temperature was still high there being no free febrile interval between the pneumonia and the empyema.

The metapneumonic empyema described by older observers following lobar pneumonia a week or ten days after defervescence was characterized by an encapsulated collection of thick creamy pneumococci pus causing fever and sweats but not cyanosis or severe prostration and having a fairly low mortality. This type however has become less frequent than the more fulminating form just depicted.

Most fatal is the empyema caused by the sudden rupture of an abscess into a defenseless virgin pleural cavity. The overwhelming onslaught is comparable to that of a fulminating diffuse peritonitis from a ruptured bowel. A rapid thready pulse delirium great prostration cyanosis and dyspnea are noted the temperature and leukocyte count are usually high but both may be low. If a ruptured lung abscess or a ruptured secondarily infected tuberculous cavity is at fault the thorax may contain a small amount of foul turbid fluid surmounted by a large amount of air under pressure. In these dangerous fulminating pleuritis large doses of sulfonamides orally should be of especial value and likewise penicillin both instilled into the pleura and administered intravenously or intramuscularly.

Putrid empyemas containing gas forming anaerobes belong to this category it is likely that small cortical pulmonary abscesses or patches of lung gangrene underlie them for it is difficult to understand how anaerobes which are not blood borne organisms could reach the pleura otherwise. Comparatively innocent localized although

excessively foul empyemas of this kind are not infrequently seen in the aged.

Every pyopneumothorax no matter how unheralded its onset must be regarded as tuberculous until proved otherwise for the commonest cause of this accident is the rupture of a tuberculous pulmonary cavity. The aspirated pus and the sputum as well should be examined for tubercle bacilli and the x-ray plate should be scrutinized for evidences of tuberculosis in both sides of the chest. All of these fulminating forms of empyema many of which contain gas and pus under much pressure should be treated by intercostal trocar drainage.

*Encapsulated empyemas* occupy a midposition between the acute and chronic forms. They occur if the suppuration has been preceded by a dry adhesive pleurisy or if the pleura has suffered recurrent inflammatory attacks. Diaphragmatic mediastinal and interlobar collections especially those encapsulated deep in the interlobar fissures far from the costal pleura may be difficult to recognize and extremely difficult to differentiate from a consolidated airless lobe of the lung. Prolonged observation outlining the lung under the x-ray with opaque oil injected into the bronchi and the aspirating needle will usually identify them sooner or later. Small localized collections may often be needled to advantage under the guidance of a fluoroscopic screen they should be drained by an accurately placed rib resection. Great care should be taken not to open the unaffected pleura the pocket should be entered with an aspirating needle after the rib has been resected and the needle should be followed by a knife or a cautery. The opening should be drained by a large rubber tube. If after the rib has been resected the encapsulated pus collection can no longer be encountered operation should be stopped before the pleura is entered and the wound should be packed. It is not legitimate to enter the unaffected pleura with the idea of exploring for an abscess for it is entirely likely that one or both of two disasters will happen either that adhesions holding the lung to the costal pleura will part and allow the lung (and with it the pus contained between its lobes) to retreat to inaccessible depths or that the localized empyema will rupture into the previously uninfected and

defenseless free pleural cavity. If the operation is stopped and the wound packed adhesions will form that may allow the abscess to be opened later with safety.

*Effusions* in the neighborhood of acute inflammatory processes usually begin as serous exudates and may remain so they may however go on to suppuration they are often more or less encapsulated such diaphragmatic pleuritis more or less regularly accompany subphrenic abscess amebic abscess of the liver and abscess of the spleen the lymphatic current flowing from below the diaphragm upward. These basal empyemas may mask the underlying subphrenic suppuration and make its recognition difficult. They may at times be drained to

eign bodies especially lost or forgotten drainage tubes and gauze in neighboring foci such as osteomyelitic ribs which continue to discharge pus into the pleural cavity or in bronchial fistulas the openings of which may be imperceptibly small. Finally underlying chronic disease of the lung prevents its reexpansion to fill the pleural cavity.

Unrecognized empyemas may discharge spontaneously (empyema necessitatis). An abscess bulges usually in the lower portion of the chest near the sternum and either perforates or is incised discharging an amount of pus which incredibly copious though it may be is rarely copious enough to effect a cure.

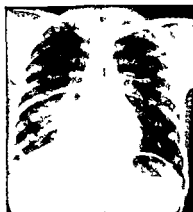


Fig 45



Fig 46

Fig 45—Roentgenogram of effusion between the upper and middle lobes of the right lung posterior or anterior projection

Fig 46—Lateral projection (Figs 475 and 476 courtesy of Dr Joseph LeVitin)

gether with the underlying abscess by an incision which enters the pleura traverses the diaphragm and ends in the subdiaphragmatic space. Similar effusions may collect around osteomyelitic vertebral bodies or ribs and other foci of suppuration.

#### CHRONIC PLEURISY AND CHRONIC EMPYEMA

An empyema is or becomes chronic for four reasons. 1 It has not been recognized and treated. 2 The infecting organism is of a kind that in itself causes chronic suppuration e.g. the tubercle bacillus actinomycetes etc. 3 There is a local cause for chronicity which is to be sought in an unextinguished focus of suppuration. Such local causes may lie in a partially sealed off pocket of pus within the pleura itself in for

The pleura of a chronic empyema becomes thicker and harder and more inelastic as time goes on it may be an inch or more thick it crunches under the knife it has no toughness and stitches cut through it as they would through a raw potato it has no blood supply and does not bleed when cut. The thickening affects mainly the costal pleura much less the visceral one so that while the costal pleura may be an inch thick the lung may be covered by no more than  $\frac{1}{8}$  inch of thickened pleura. The thickening hardening and inelasticity explain the shrinkage and rigidity of the chest wall that accompany chronic empyema they explain the distortion not only of the mediastinal viscera but of the whole torso the scoliosis and also the porosity of the ribs which

immured in such a cuirass atrophy from disuse. Occasionally these thick pleural crusting are lined with large thin chalky plaques which beset them like oyster shells rarely they contain true deposits of bone between their layers. Chalky plaques are found most frequently in chronic empyemas of the aged. In tuberculous empyema the pleura may be lined with typical epithelioid tubercles; ordinarily these old thick pleuras are almost devoid of cellular elements.

There is one type of *chronic proliferative pleurisy* without exudation and without suppuration which is more of pathologic than clinical interest. Except over the pulmonary apices where it often accompanies an old fibrous tuberculosis it is rare when extensive it may cause scoliosis and other deformities of the trunk. Syphilis may produce such a type.

Recognition of the underlying cause of chronicity may be difficult not only the pus but sections of the pleura should be examined.

**Chronic Pyogenic Empyema**—Chronic pyogenic empyema often causes recurrent attacks of fever the patient is pale and emaciated and has much the appearance of a phthisic. A small sinus or a tiny drainage tube often discharges profusely the chest as may be expected from the description of the pleura is shrunken and distorted and does not move on respiration. The x-ray picture discloses a massive density in which films of higher penetration may reveal cavities with a fluid level or faint shadows of calcification or of foreign bodies. If one is fortunate enough to find a curable focus of suppuration a loose foreign body or a half sealed off pocket which can be drained efficiently the apparently most hopeless empyema may heal the heavy fibrous pleural thickening may be absorbed and the chest may regain its mobility. If small recurrent bronchial fistulas cannot be closed they may be shut off from the pleura by packing and brought to the surface through a properly placed rib resection (marsupialized). If all efforts fail thorough mobilization of the chest wall by a series of extensive rib resections which lay the infected cavity and all its overhanging edges wide open will usually bring the infection to an end after which the wound may be closed by a plastic opera-

tion. These operations are difficult and entail considerable risk. Fresh air sun baths and a liberal diet high in proteins and vitamins aid greatly in overcoming the effects of chronic suppuration.

**Tuberculous Empyema**—Most primarily chronic empyemas are tuberculous. Tuberculous empyema may be divided into two categories uncomplicated sterile tuberculous empyemas and secondarily infected ones. The incidence of both forms has risen greatly since therapeutic pneumothorax has come into common use. The incidence of purulent effusion in artificial pneumothorax is given variously at from 6 to 41 per cent. The frequency of tuberculous empyema therefore is apparent when one considers that there are many thousands of tuberculous patients in the United States alone who are receiving pneumothorax. Tuberculous empyema may be primary or secondary to pulmonary tuberculosis. In the so called primary form a hidden focus may be found in suppurating caseous mediastinal lymph nodes which have broken through into the pleura.

Symptoms of the disease vary greatly some patients may harbor a large effusion and complain of nothing but moderate dyspnea or fullness in the chest others have a high temperature and drenching sweats and are profoundly toxic. The signs are those of a pleural effusion pulmonary involvement may be entirely absent. In febrile patients it may be difficult or impossible immediately to distinguish between tuberculous and ordinary acute suppurative empyema yet the diagnosis is of paramount importance for to treat a tuberculous empyema by open drainage is usually fatal. The most important factor in arriving at a diagnosis is to think of the possibility of tuberculosis. Pus mixed with clots of fibrin with no organisms demonstrable by smear or culture is always highly suggestive of tuberculosis. The pus may contain myriads of acid fast bacilli more often none can be demonstrated in a smear. When in doubt it is usually wise to await the results of guinea pig inoculation or culture for tubercle bacilli.

**Treatment of uninfected tuberculous empyema** is still under dispute. In some cases spontaneous healing is obtained with simple rest in bed and proper hygienic measures.

The amount of the effusion may demand aspiration but repeated aspiration usually leads to secondary infection. Substitution of the tuberculous pus with antiseptic oil (oleothorax) has led to cure. Persistently toxic febrile patients have been cured by a flap operation as described in the section on treatment of acute empyema.

Secondarily infected tuberculous empyemas including closed and communicating ones are extremely serious. The pleura may communicate with the exterior through a bronchial fistula or through an open chest wound or tuberculous sinus. A roentgenogram of an open empyema which demon-

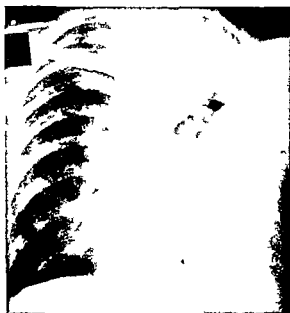


Fig. 4.—X-ray of an endothorax of the pleura. Large tumor masses fill out almost the entire left pleural cavity.

strates an entirely collapsed and retracted lung is highly suggestive of tuberculosis. The lung in a non tuberculous empyema has no such tendency to remain entirely collapsed. The patient is often profoundly toxic and soon succumbs to fever, sepsis, and old disease or distant tuberculous foci. The valve flap has been useful in obliterating the pleural space even in secondarily infected tuberculous empyema. After the pus has been drained and acute symptoms have subsided a more or less extensive thoracoplasty may be indicated if any of the empyema cavity remains to be obliterated.

Tuberculous empyemas communicating with a bronchial fistula must be drained

through the chest wall for constant cough and profuse expectoration soon exhaust the patient. (See the section on Surgery of Pulmonary Tuberculosis.)

**Actinomycosis of the Pleura**—Actinomycosis of the pleura causes huge hard deposits with periostitis and erosion of the ribs and vertebrae. The periostitis and erosion are typical of actinomycosis and occur in no other form of empyema. Large brawny infiltrates involving the whole thickness of the chest wall and multiple sinuses surrounded by easily bleeding granulations are characteristic of this disease. The sulfonamides and especially penicillin have led to striking results in the treatment of pleural actinomycosis which prior to their introduction was almost always fatal.

#### NEOPLASMS OF THE PLEURA

Pleural neoplasms are primary or metastatic the latter being more frequent. They may reach the pleura by continuity or via the lymph stream as in the carcinomatous pleurisy of cancer of the breast in which the pleura is studded with milium cancerous nodules they may take the form of tertiary nodules in which a distant tumor causes pulmonary metastases which in turn reach the surface of the lung and spread into the pleural cavity. The cancerous pleura exudes a fluid which may be serous or more often blood tinged. If the primary tumor remains undiscovered the true nature of the pleurisy may be not easy to determine. A bloody fluid will awaken suspicion, even the unstained centrifugate may contain microscopically recognizable clumps of tumor cells. Stained sections of the embedded sediment are more likely to lead to a correct diagnosis. Mottled erosion and involvement of the ribs visible in a roentgenogram are equally pathognomonic while actinomycosis may cause similar erosion it rarely causes a massive serous exudate. The disease is hopeless even cancer of the breast which is amenable to radiotherapy is refractory once it has settled in the pleura.

**Hodgkin's Disease**—Hodgkin's disease of the pleura manifests itself in a variety of forms: milium nodules, larger nodules and large tumor masses, diffuse pleural thickening, and a chronic sclerosing form have been described. The disease may cause the exuda-



tion of large amounts of a more or less turbid at times in almost purulent exudate and at times a chylothorax. It may extend to the pleura from the mediastinal cervical axillary or intercostal lymph nodes or from a lymphoblastomatosis of the lung. Diagnosis will rest on the presence of Hodgkin's disease elsewhere and the identification of typical giant cells in the exudate. Bits of tissue may be removed with a large aspirating needle or by exploratory thoriotomy. Small doses of x-ray may give prolonged relief. Sunbaths, arsenicals, codliver oil and rest in bed are also beneficial when used together with the x-ray.

**Benign and Malignant Primary Neoplasms**—Of the numerous varieties of benign and malignant primary neoplasms which occur in the pleura two have clinical importance—the endotheliomas or mesotheliomas and the sarcomas. The exact histologic nature of the endotheliomas or mesotheliomas has been the subject of endless discussion. They form wide diffuse masses projecting into the pleural cavity at times as condylomatous villi and at times as solid lumps. They may make massive exudates, the more fluid they form the flatter they seem to be, they rarely invade the lung but involve visceral and costal pleura alike. They involve the regional lymph nodes regularly and in three fourths of all cases they involve both sides of the chest. The right side is affected somewhat more often than the left.

All forms of sarcomas occur, fibrosarcomas and lymphosarcomas chiefly. They more often form large nodular masses than do the endotheliomas which are flatter. They involve the left side twice as often as the right.

The endotheliomas when first seen often have attained a size and an extent that preclude operative attempts at removal, although occasionally exploratory thoriotomy may be justified. Sarcomas tend to remain somewhat more localized and in instances of successful resection of these growths have been recorded.

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### POSTOPERATIVE ATELECTASIS, PULMONARY ABSCESS, GANGRENE AND BRONCHIECTASIS

#### POSTOPERATIVE ATELECTASIS

(*Marine Collapse of the Lung Drowned Lung*)

**Definition**—Atelectasis is a condition of complete uselessness of a lobe or a lung (massive collapse) or of a group of lobules (lobular or patchy atelectasis). Atelectasis is the most frequent postoperative pulmonary complication; it is often mistaken for pneumonia.

**Pathology**—The involved portion of the lung is completely useless, solid and much smaller than normal. The bronchus and its divisions that lead to the involved area are usually occluded by tenacious purulent mucus. The decrease in the size of the lung is compensated for by traction displacement of the surrounding structures: the heart or the heart and trachea may be entirely in the diseased side of the chest; the hemidiaphragm is elevated and the ribs are depressed. The contralateral lung and the unaffected portion of the diseased lung are overdistended.

Van Allen and Jung have shown that occlusion of a branch of a bronchus within a normal lobe does not result in atelectasis because interalveolar pores maintain an interlobular or collateral circulation of air. If however the alveolar walls should be diseased and the pores sealed, the collateral circulation of air may be prevented; atelectasis of a part of the lobe would then occur.

**Etiology**—Complete occlusion of a lobar bronchus prevents air from entering the part of the lung supplied by that bronchus and the air that is already in the lung becomes absorbed by the blood within an hour or so. As the air is absorbed the walls of the alveoli and smaller bronchi are drawn together. The mediastinum, diaphragm and ribs follow the shrinking lung.

flex inhibition of the inspiratory muscles muscular weakness tight strapping of the upper abdomen and lower thorax abdominal distention or too large doses of opiates. Possible causes of increased production of tenacious bronchial secretions are pre-existing bronchitis, allergy and an irritating anesthetic agent (though atelectasis often occurs after local or spinal anesthesia).

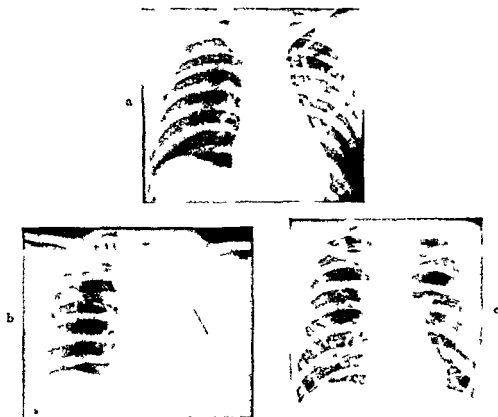


FIG. 478.—a Two days after lateral pleural herniorrhaphy under combined avertin and nitrous oxide anesthesia. The shadows in the left lung suggest early patchy atelectasis or bronchial pneumonia; the heart is slightly displaced to the left. Dyspnea, a temperature of 103.8° F., 17,000 white blood cells, mucopurulent temporarily reddish sputum and abdominal distention were noted. The day before this roentgenogram was made there was much mucus in the trachea (and presumably in the bronchi) which the patient could not expectorate. b Four days later. Massive collapse of the entire left lung; the heart is greatly displaced to the left (the left border is indicated by an inked line); the diaphragm cannot be clearly seen. Persisting dyspnea but less fever and fewer leukocytes were noted. Treatment consisted of (1) inhalations of carbon dioxide in oxygen every three hours day and night, for the next two days and then less frequently; (2) flaxseed poultices and rectal tube for relief of abdominal distention; (3) intravenous fluids. c Four days later. Complete expansion of the collapsed lung and return of the heart to a normal position. There are no symptoms.

Occlusion of a bronchus by secretions is due to aspiration of oral secretions and retention of bronchial secretions owing to inadequate pulmonary aeration and ventilation and especially to ineffective coughing and expectoration. Decrease of respiratory excursions after operation, especially an operation on the upper abdomen, is chiefly due to pain, a fixed position of the body, re-

**Symptoms and Physical Findings**—The prompt recognition of the prodromal signs of atelectasis and complicating postoperative pneumonia is necessary for effective preventive treatment. These signs are frequent moist cough that continues to be moist even though some secretions have been expectorated, persisting rales, wheezes and diminished breath sounds by auscultation.

tion over the pulmonary base or bases elicited best during forced deep breathing or coughing perhaps slight dullness to percussion shallow rapid respiration rapid pulse and slight cyanosis. With the development of atelectasis the temperature and the pulse and respiratory rates mount cyanosis increases and in severe cases the patient may become comatose the wet cough is likely to be frequent and although some sputum may be raised the physical signs show that many secretions remain in the lung dullness of the affected lobes increases the breath sounds diminish and traction displacement of the mediastinum and diaphragm occurs.

If the secretions plugging the bronchi are evacuated within a few hours the lung may immediately become aerated (Fig 4-8 c) and all abnormal signs and symptoms except temporary expectoration disappear. If however bronchial obstruction is not relieved promptly and the bronchi are not kept patent by the efficient evacuation of all secretions infection is likely to develop in the obstructed segments of the lung producing a bronchial pneumonia which may prove fatal.

**Diagnosis.**—Moist ineffectual cough basal rales wheezes diminished breath sound and dullness with increasing fever and cyanosis are virtually diagnostic of developing atelectasis. A diagnosis of atelectasis is confirmed by traction displacement of the mediastinum and diaphragm which helps to distinguish atelectasis from pneumonia pleural effusion acute dilatation of the heart, coronary thrombosis pulmonary embolism and diaphragmatic hernia.

**Prognosis.**—Atelectasis of a lobe or even an entire lung is in itself not fatal although the anoxemia and increased cardiac labor that it produces may contribute to a fatal outcome of the disease for which the operation was performed. The possible complications of an atelectasis that is not promptly relieved viz pneumonia pulmonary abscess bronchiectasis and empyema are serious and may be fatal. Recognition and treatment of the pre atelectasis stage of the condition are likely to prevent the development of a grave postoperative pneumonia. Early diagnosis of atelectasis and immediate adequate treatment bring about a cure without complications in a great majority of cases.

**Treatment.**—The following measures are highly effective in preventing postoperative atelectasis and pneumonia deep breathing coughing and if possible expectorating shortly before operation no atropine before or after operation not enough morphine before or after operation to obtund the cough reflex no anesthetic agent (e g avertin) that prolongs sleep after operation a 15 degree Trendelenburg position of the operation table when feasible gentle operating no tight strapping of the operative wound postoperative change of position every two hours so that each side is occasionally uppermost (the side having the more secretions and rales should be kept uppermost the longer time) voluntary (or induced by inhalation of from 10 to 15 per cent carbon dioxide in oxygen) deep breathing coughing and expectorating every three or four hours while a painful incision is manually supported by a physician or nurse Coughing and expectoration are favored by the Fowler position in some cases and by the Trendelenburg position in others. Secretions that cannot be expectorated should be promptly and if necessary repeatedly removed from the trachea and bronchi by Haight's method of intrabronchial catheter aspiration. Secretions too tenacious or abundant for removal by catheter should be removed bronchoscopically.

If neglect of these preventive measures results in atelectasis this should be treated by an intensive application of the same measures. The use of oxygen by intratracheal catheter or by tent is advisable until the atelectasis has disappeared and until the patient is able to expectorate with proper efficiency.

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### NON TUBERCULOUS PULMONARY ABSCESS AND GANGRENE

**Definition**—A non tuberculous pulmonary abscess is a suppurating liquefying infection of the pulmonary parenchyma. Gangrene is the non purulent death *en masse* of pulmonary tissue. Since these two conditions are often associated and are treated in the same way they will be considered together here under the inclusive term of abscess.



Fig. 479.—The lung had opened vertically to show a suppurative pulmonary infiltration and the necrotic irregular interior wall of an abscess in the subacute phase. The right-hand end of the probe passes through a perforation in the cortex and visceral pleura. It has been sealed by fresh adhesions. The inserted photograph shows another section of the same abscess and a daughter abscess which communicates through a narrow channel that is occupied by the probe. The probe points toward one of several open bronchi.

**Pathology**—An area of suppurative infiltration in the bronchioles or alveoli becomes transformed by necrosis and liquefaction into a pus containing cavity. The wall of the cavity may be thin or thick or composed of an extensive area of pneumonic infiltration. Early or late the pus within the cavity ruptures into a bronchus or occasionally into the pleural cavity causing an

empyema with or without a persisting bronchopleural fistula. Inflammatory pleural adhesions however usually prevent perforation into the pleural cavity (Fig. 479). After rupture into a bronchus the cavity may become filled with air or remain filled with grumous secretions or it may be filled with air and secretions (Fig. 480). The lumen of the bronchus leading from the abscess is often too narrow for adequate drainage of the secretions; the bronchial mucous membrane may be swollen and heaped with granulation tissue or the bronchial lumen may be occluded by a foreign body or tumor, cicatricial contraction or extrabronchial pressure. Because of poor drainage by bronchus the abscess continues to be filled by secretions or filled partly by secretions and partly by air (Fig. 480).

Abscesses may occur in any lobe usually near the periphery and only rarely in the central or hilar zones. In a great majority of cases the abscess is within 1.5 cm. of the costal pleura and in a minority the abscess is in the cortex of the lung deep in one of the interlobar fissures or next to the mediastinum or diaphragm. An abscess may be single or multiple. When multiple they usually lie close together and may communicate through narrow channels (Fig. 479). Bands of tissue which are composed of bronchi or patent or thrombosed blood vessels may span an abscess or form ridges on its wall.

**Etiology**—Abscesses tend to occur in debilitated persons with pyorrhea alveolaris. The following sequence of events probably represents the etiological factors in the majority of cases: (1) the aspiration of infectious secretions from the gums, tonsils or sinuses into the lung during operation (especially on the teeth, tonsils or sinuses) or during sleep also aspiration of food vomitus, water or other foreign bodies during submersion; (2) stasis of the aspirated secretions because of diminished respiratory movements and inefficient coughing chiefly due to prolonged deep anesthesia; postoperative pain or too large doses of morphine; (3) sufficiently long contact of the infectious secretions with the pulmonary tissue to establish an infectious process.

Other causes of abscess are suppuration and liquefaction within an area of delayed

resolution of pneumonia or within a pulmonary neoplasm or cyst; an embolus from an operative wound; pyemia; trauma of the lung with secondary infection; extension of infection from bronchiectases, and mycotic lesions. Streptococci and other pyogenic organisms are usually the causative agents, spirochetes and other putrefactive organisms are frequent secondary invaders. The putrefactive organisms are usually the primary agents in pulmonary gangrene and in the so-called putrid abscess.

**Symptoms.**—The symptoms of onset may appear suddenly or insidiously and in-

Costal and diaphragmatic movements are restricted on the affected side. If the lesion is not too small, fremitus is usually increased and the percussion note impaired. In most cases the auditory signs are those of a small patch of pneumonic consolidation with râles, though the breath sounds may be diminished or absent; cavernous signs are sometimes demonstrable, a pleural friction rub may be heard. A localized area of intercostal or periosteal tenderness indicates the place where the abscess is most superficial.

Roentgenologically, there is usually an irregular area of density in which a small air



Fig. 480.—a, Abscess of the lower lobe filled with air and pus seven weeks after partial gastrectomy, arrows indicate the limits of the abscess as determined the next day at open operation. b, Several days after drainage of the abscess. The clear area lateral to the costal stumps is due to an operative defect in the thoracic wall. The arrow indicates the position of a second abscess containing pus but no air. The existence of a second abscess was suspected when abundance of sputum persisted after drainage of the first abscess. The second abscess was drained nine days after the first operation and was found to be 9 by 4 cm. in size. c, End result nine months after drainage: no cough or expectoration remains, and the wound is healed. \* Today only a short piece of one rib would be resected for the drainage of each abscess.

clude varying degrees of malaise, fever, cough, expectoration and, perhaps, pleural pain, chills, dyspnea and cyanosis. At first there may be no sputum; it may appear in small amounts and gradually increase, or, following the sudden rupture of a large abscess into a bronchus, a tremendous amount of sputum may be evacuated within a few minutes (vomica). The sputum is purulent; it may be odorless, but usually it has a fetid or sweetish odor. The first expectorated material may be pure blood, large or small hemoptyses or blood-streaking of the sputum may recur throughout the illness.

pocket can often be seen; this air is within the abscess cavity, the greater part of which is filled with heavy secretions. In some cases a considerable amount of air is present in the cavity (Fig. 480, a), while in others the cavity is completely filled with secretions which give a roentgenologic shadow that is homogeneous with the abscess wall (Fig. 480, b). Potter-Bucky roentgenograms may be necessary to demonstrate air-containing cavities within a densely infiltrated lung. Bronchograms should rarely be made, because lipiodol may induce a dangerous pneu-

monitis in cases of acute abscess and be cause the lipiodol is more likely to indicate merely a filling defect in the region of the pulmonary infiltration than to enter the abscess

In cases in which the suppurative infiltration and excavation are progressive the patient becomes increasingly toxic and dies from the effects of the overwhelming infection or from brain abscess rupture of the lung and fulminating empyema large hemoptyses or suppurative pneumonitis In chronic cases with less severe infection pulmonary fibrosis extension of the infection bronchiectasis clubbed fingers and toe nephritis and amyloid disease often grad

and bronchogenic carcinoma The difficulty of diagnosis is increased by the fact that each of these conditions may be complicated by pulmonary abscess The differential diagnosis can however almost always be made by the careful weighing of the findings in their relation to the characteristic features of the various diseases Diagnostic aspiration of an abscess through the skin should never be undertaken because of the danger of infecting the pleural cavity and tissues of the thoracic wall via the needle track

**Prognosis**—Possibly as many as 30 or 40 per cent of patients with uncomplicated abscesses recover spontaneously without

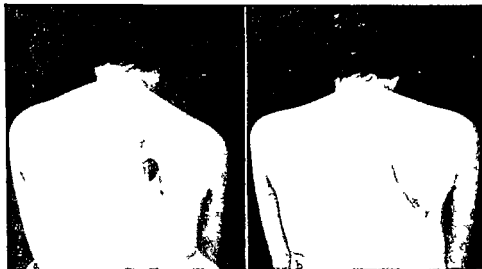


Fig 481—*a* First sized abscess with many open bronchi in the lower lobe approximately one year after surgical drainage the sputum and purulent wound discharge are now absent *b* Eighteen days after filling of the abscess cavity and occlusion of the open bronchi with a large pedicled muscle graft There is no sputum and closure of the bronchi and of the incision is complete

ually develop Remissions and exacerbations of symptoms may be expected

**Diagnosis**—A history of an operation or aspiration of a foreign body followed by an acute illness with the expectoration of abundant foul purulent sputum which has been repeatedly found to be free of tubercle bacilli the absence of traction displacement of the diaphragm and heart and the presence of the physical and roentgenologic signs that have already been considered are findings that are virtually diagnostic of abscess

Diagnostically abscess may be confused with tuberculosis bronchiectasis empyema with bronchopleural fistula a subphrenic abscess that has ruptured into a bronchus

other treatment than bed rest If such recovery does not occur within two months after the onset of symptoms it is unlikely to occur Usually only the patients with severe complicated or chronic cases reach the surgeon and in approximately 5 or 10 per cent of the acute cases and 20 per cent of the chronic cases death occurs The prognosis depends chiefly on the adequacy of bronchial drainage the virulence of the infection the patient's general condition and specific resistance and the extent duration and complications of the lesions at the time that effective treatment is begun The prognosis depends largely upon carrying out surgical drainage very early in the disease as has

been amply demonstrated by Neuhof and Touroff.

**Treatment.**—Prophylactic treatment is essentially the same as that described in the section on treatment of atelectasis (see previous section). A patient with an acute abscess should be strictly confined to bed under a sanatorium regimen. He should not sleep on the undiseased side, because of danger of gravitation of infectious secretions to the undiseased lung while the protective cough reflex is relatively inactive. Postural drainage should be effected every two hours while the patient is awake. In occasional cases in which bronchial drainage is free, the hemidiaphragm should be temporarily paralyzed in order to rest and relax the affected area. Bronchoscopy should be tried at least once and continued at three day or five day intervals only if great improvement occurs; the aspiration of secretions, the shrinking of the swollen mucous membrane and the possible detection and removal of a foreign body promote adequate bronchial drainage which may initiate healing. Pneumothorax is dangerous treatment for a non-tuberculous abscess, and thoracoplasty is only rarely indicated. Vaccines are probably of no value. When spirochetes are present in the sputum, a course of salvarsan or neosalvarsan may be given intravenously. Blood transfusions are useful for severe anemia.

Until a few years ago there was an almost universally accepted dictum that no acute pulmonary abscess should be surgically drained within eight or ten weeks of its onset. The clinical demonstration by Neuhof and Touroff that this practice leads to a high mortality rate and great morbidity has caused a rapidly increasing acceptance of their advice to drain abscesses as soon as a diagnosis has been made and a brief trial of other measures has failed to indicate rapid progress toward a cure. These surgeons stress the importance of accurate localization and one stage drainage after the resection of a short piece of only one rib where the abscess is most superficial and where the pleurae are adherent. Cautery drainage must include any secondary abscesses that may be present and may need to be so extensive as to constitute partial lobectomy. After complete disappearance of sputum and of purulent discharge from the wound

following drainage, bronchial fistulas that do not close spontaneously should be closed with applications of a 35 per cent solution of silver nitrate or with a pedicled muscle or

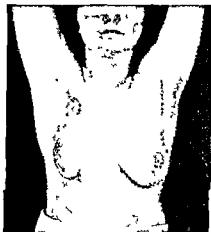


Fig 482.—Implantation of the breast to fill a tremendous intrathoracic defect and to occlude the large open bronchi that followed destruction of the entire upper and most of the middle lobes by multiple progressive abscesses and many cauterization drainage operations. There is no sputum and closure of the bronchi and of the incision is complete.

skin graft (Figs 481 and 482) or with Neuhof's free fat graft. Occasionally, total lobectomy should be performed in resistant cases of huge abscess or multiple abscesses.

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#### BRONCHIECTASIS

**Definition.**—Bronchiectasis is a chronic condition of dilatation of the bronchi, which are usually infected and secrete abundant pus.

**Pathology.**—The lesions are bilateral in approximately half of all cases. They may be confined to any one lobe (especially the left lower), but more frequently they involve the left lower and the lower part of the left upper lobes, or the right lower and middle lobes.

Peripheral or bronchiolar bronchiectasis

involves the small bronchi and bronchioles whereas the common central bronchiectasis involves the larger bronchi. The dilations are saccular or cylindrical. The pulmonary parenchyma surrounding central bronchiectases may be almost entirely normal, the covering pleurae glistening and without adhesions and the lung normal to palpation except perhaps for some hard lumps. Frequently, however, the parenchyma is the seat of fibroid pneumonitis, the lobe is shrunken, dark and indurated and its pleurae are adherent. The diseased parenchyma may contain abscesses. In emphysema with or without a bronchopleural fistula may be present.

Chronic bronchiectasis is a complication of nasal sinusitis, secretions a retained bronchial foreign body, intrabronchial neoplasm, tuberculous or non-tuberculous granulation tissue or fibrous stricture of a bronchus and extra-bronchial pressure by enlarged lymph nodes or other masses. Pulmonary abscess and tuberculosis (without bronchial stricture) are infrequent precursors of bronchiectasis although they are occasionally complicated by patches of bronchiectases. Some cases of bronchiectasis are congenital in origin. Allergy coexists with bronchiectasis in many cases and a few observers believe that allergy is a frequent cause of bronchiectasis.

**Symptoms**—The most prominent symp-



Fig 483—Bronchograms of the three lobes of the right lung showing a normal upper lobe and bronchiectasis of the middle and lower lobes. As the shadows of the middle and lower lobes are superimposed on the postero-anterior projection on roentgenogram only the lateral projection roentgenogram clearly shows that both the lower (posterior) and the middle (anterior) lobes are involved.

**Etiology**—Bronchial pneumonia (often complicating measles or pertussis in childhood or influenza) is the commonest precursor of bronchiectasis. The probable explanation is that stagnation of secretions in the bronchi partly produced by poor pulmonary ventilation causes patchy or lobular atelectasis and the resulting highly negative intrathoracic pressure, not being absorbed by the inelastic atelectatic lung, is transmitted to the bronchi which dilate. Concomitant infection in the bronchial walls weakens them and the dilatation remains even after disappearance of the atelectasis. Conditions less frequently leading to bron-

chiectasis are persistent abundant expectoration. The sputum may be either foul or non-odorous, blood-streaked, or recurring large hemoptyses are not uncommon. There are no bronchial secretions in bronchiectasis sicca. Fever is rare when there is no bronchial obstruction or complicating suppurative pneumonitis. Clubbed fingers and toes and nasal sinus infection are frequently present.

The physical signs of even extensive central bronchiectasis (without accompanying pneumonitis) are often within normal limits, though there may be a slight increase in fremitus and a few rales. When pneumonitis



is present the signs are those of varying degrees of pneumonic consolidation with or without signs of cavitation

The symptoms and signs that have been mentioned are common to bronchiectasis, abscess, certain empyemas with broncho-pleural fistula and some cases of tuberculosis. Bronchograms offer the most certain means of diagnosing bronchiectasis (Fig 483). The opaque oil which fills the bronchi or coats their walls (unless retained secretions or organic bronchial stricture prevents the passage of the oil) clearly demon-

**Diagnosis**—Although the diagnosis can often be tentatively made on the basis of the history and symptoms, a definite diagnosis and determination of the extent of the disease depend on bronchograms. Before these are made bronchoscopy should be used to detect a possible foreign body or neoplasm. The separation of the sputum into three layers after standing is of little diagnostic value.

**Prognosis**—Bronchiectasis which is essentially a chronic disease is so variable in its behavior that it is impossible to foretell



Fig. 484—Twenty two days after removal of the left lower and lingular lobes for bronchiectasis. No deformity or dysfunction of the shoulder girdle resulted.

strates the bronchiectases even in the left lower lobe behind the heart. Roentgenograms without iodized oil show no abnormalities or perhaps only small ring shadows unless there is associated pneumonitis.

Stewart Pritchard and Ross found that their 60 bronchiectatic patients had a total of 240 complications. Common complications are disease of the nasal sinuses, recurring attacks of pneumonia, or acute extension of the lesions of suppurative pneumonitis, hemoptyses, nephritis, amyloid disease, myocardial degeneration and brain abscess.

accurately either the expectancy of life or the course and severity of future symptoms. The chance is great, however, that the patient will suffer serious illness or will die within five years of the onset of the disease. Except possibly in early cases in children, the dilated bronchi never return to their normal caliber. Appropriate treatment may greatly reduce infection and enable the patient to live indefinitely with few disturbing symptoms. In some cases no treatment except actual removal of the diseased tissue by lobectomy is able to check the infection.

and to prevent complications. Death from bronchiectasis is usually due to some complication the most common being pneumonitis the effects of prolonged toxicity and brain abscess. A few patients commit suicide because of the stench and the great amount of sputum. Even massive pulmonary hemorrhage is in itself rarely the cause of death.

**Treatment.** — Prophylactic treatment should be directed toward the immediate removal of an intrabronchial foreign body eradication of infection in the gums and nasal sinuses active treatment of delayed resolution of pneumonia by prolonged strict bed rest a trial of one of the sulfonamides and of penicillin postural drainage every two hours possibly temporary or permanent paralysis of the phrenic nerve one or more courses of neosalvarsan if spirochetes are present in the sputum repeated bronchoscopic aspiration of secretions shrinkage of swollen mucous membrane and dilation of any bronchial stricture.

The measures that have just been named should be used for an established case of bronchiectasis though it is doubtful if neosalvarsan is of value in a chronic case. Postural drainage is indispensable and if the bronchi are kept relatively free of stagnant secretions infection in their walls tends to subside the amount of sputum the odor and hemoptyses tend to lessen and the patient's weight and general condition improve. Although in a majority of cases phrenic paralysis proves to be of no benefit it sometimes stops hemoptyses and greatly reduces the amount of sputum if it is found to be effective a temporary paralysis may be made permanent. Blood transfusions should be used for severe anemia that does not respond to the administration of iron. Vaccines are of no value. Residence in a warm dry climate may prevent recurring attacks of pneumonitis improve the sinus infection and lessen the amount of bronchial secretion.

Pneumothorax probably should not be used for bronchiectasis though occasionally when pleural adhesions do not prevent an adequate pulmonary collapse great improvement may attend this procedure remission is likely to occur after abandonment of the pneumothorax. Thoracoplasty is a danger-

ous operation in bronchiectasis and only exceptionally produces any lasting benefit. Thoracoplasty may however be indicated in certain cases of the rare peripheral type of bronchiectasis and in cases in which there is great traction displacement of the mediastinum because of pulmonary and perhaps pleural fibrosis. Surgical drainage of the bronchiectases should not be used though occasionally a large complicating abscess demands drainage. An area of bronchiectasis restricted to a small portion of one lobe may be destroyed by a staged cauterization operation.

For the patient whose lesions resist the various measures that have been discussed and whose disease is severe because of toxicity abundant foul sputum recurring at attacks of pneumonia or large hemoptyses lobectomy should be considered or even pneumonectomy if the disease occupies an entire lung. The patient should be in reasonably good general condition preferably less than forty-five years of age and the lesions should be confined to one lung or at least minimal in extent in the less diseased lung. The surgical risk of bilateral lobectomy for bilateral bronchiectasis is relatively great. The death rate from unilateral lobectomy has been reduced in several clinics to less than 5 per cent which is considerably less than the risk to life of the disease itself. A successful operation causes complete disappearance of all symptoms of bronchiectasis (Fig. 484).

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#### TUMORS OF THE LUNG AND BRONCHI

##### PRIMARY CARCINOMA

Carefully evaluated statistics appear to indicate that the incidence of primary carcinoma of the lung has definitely increased

Various causes have been invoked, among them the inhalation of tar dust from roads the influenza epidemic of 1918 and tobacco smoking. A high incidence of primary carcinoma of the lung has been observed for centuries among the Schneeberg miners in Saxony ("Bergrkrankheit"), and the phenomenon has been attributed to the radioactivity of the ore. In general, however, the origin of pulmonary carcinoma is as obscure as that of other neoplastic disease. There is no evidence to show that pulmonary tuberculosis plays an important role as a predisposing factor.

Classifications of primary carcinoma of the lung have been based on the appearance of the disease at gross, the roentgen ray shadows and the symptomatology. These descriptions are usually without special significance based as they are on advanced stages of the disease. As with other tumors the classification on the basis of cell type will prove the most informative to the surgeon.

It is not surprising to find confusion regarding the histogenesis of primary epithelial tumors of the lung when a divergence of opinion exists in regard to the histology of the normal lung. The point at issue is whether or not the normal alveolus possesses a lining membrane of epithelial cells. Those writers who deny the existence of such a structure must perforce deny the alveolar origin of epithelial tumors and ascribe a bronchogenic origin to them from the epithelial elements of the bronchial mucous membrane to all primary carcinomas of the lung. The evidence at hand at the moment is far from conclusive and the concept of an alveolar epithelial membrane cannot be discarded or its possible role in the histogenesis of primary epithelial neoplasms ignored. On the other hand an alveolar origin cannot be established with certainty after a tumor has developed.

Bronchial mucous membrane may exhibit a marked degree of metaplasia in chronic inflammatory lesions entirely unassociated with neoplasm. The lining membrane of bronchiectatic cavities is frequently of the squamous cell type. Epidermoid carcinomas of the squamous cell type with or without epithelial pearl formation or prickly cell differentiation may be derived from the elements of the bronchial epithelium even though this structure is normally cuboidal or cylindrical in form. A single tumor may show varying degrees of metaplasia within its structure forming a polymorphic or mixed type of growth.

A simple classification of primary carcinoma of the lung based on histologic characteristics is as follows:

1 *Squamous cell epitheliomas* of the malignancy type with varying degrees of cell differentiation. Huguinin has also described a "paramalignant" type with larger polyhedral cells.

2 *Adenocarcinoma* cylindrical or cuboidal cells appearing to form gland like structures. At times the acinar structure is so differentiated as to produce a colloid type which is well demonstrated by the mucicarmine staining reaction.

3 *Small cell type* ("oat cell") a cell rich carcinoma composed of small fusiform cells with very little stroma. These tumors have frequently been termed lymphosarcomas because the cells resemble lymphocytes when sectioned transversely. The tumor is partic-

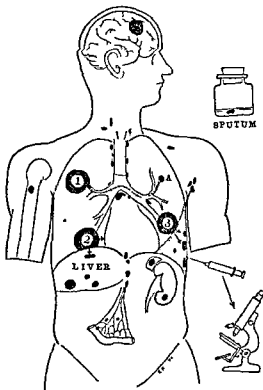


Fig 485—Metastases and routes of direct extension of three typical primary carcinomas of the lung (See text)

ularly apt to invade the mediastinum and lung in a diffuse infiltration. The histogenesis is peculiarly obscure and controversial.

#### 4 *Undifferentiated types*

**Metastases**—The conception that primary carcinoma of the lung is highly malignant and peculiarly prone to widespread extension and metastases was based on autopsy findings in advanced cases. An earlier recognition of the disease and its treatment by surgical measures has already altered this concept. Primary carcinoma of the lung spreads to distant sites by both lymphatic and hematogenous routes (Fig 485). The

bronchial and mediastinal lymph nodes may be invaded early. Blood stream metastases appear to find particularly favorable soil in the brain, the liver, the adrenals and the kidneys. Metastases of carcinoma of the lung may also be aerogenous—a method of extension peculiar to this tumor. Fragments of tumor tissue not infrequently appear in the sputum (Fig 485) and when such a fragment is conveyed to a distant part of the lung by cough it may establish a secondary focus of the disease (Fig 485 A).

As is the case with other tumors carcinoma of the lung also progresses and kills by direct extension. Common types of extension are illustrated in figure 485. Direct

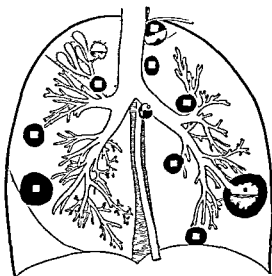


Fig 486—Pathogenesis of symptoms and signs in primary carcinoma of the lung (See text)

extension to the mediastinum is frequent and invasion of the pericardium, the great vessels or the heart muscle itself may occur. Invasion of the diaphragm may be followed by extension through its peritoneal surface and a plaque of carcinoma may be deposited on the dome of the liver.

The degree of malignancy as indicated by the rapidity of metastases and local extension has not been adequately correlated with the histologic type of individual tumors. In general the oat cell and undifferentiated types are rapidly invasive tumors poorly suited to surgical extirpation. Tumors of the squamous cell type may be expected to yield the most favorable results after surgical treatment. Careful clinical records and particularly an increased experi-

ence with surgical measures will increase our knowledge in this regard.

**Symptomatology**—Primary carcinoma of the lung is as protean in its symptomatology as it is polymorphic in its histology. Figure 486 portrays the pathogenesis of the common manifestations of the disease. It is to be emphasized that a single growth usually produces symptoms or signs by several of these mechanisms appearing simultaneously or in sequence so that the diagram is not to be interpreted as a classification of disease types.

The following headings refer to the numbers of the tumors in figure 486. Cough may be a symptom common to all of the lesions pictured and is usually the earliest and most constant manifestation of the disease. The cough may develop suddenly but more frequently its onset is coincident with an acute respiratory infection which simply means that a partially obstructed area of lung has become infected. A cough that hangs on in a patient who has previously been well deserves careful diagnostic study. Clubbing of the fingers or more extensive pulmonary osteoarthropathy may be an early manifestation of the disease.

1. A tumor in close proximity to the visceral pleura may produce a pleural effusion which may or may not be preceded by dry pleurisy. The effusion may be serous but is characteristically bloody. When actual invasion of the pleura exists (Fig 486 type 3) tumor cells may be found in the sediment of the fluid.

2. Tumors in the parenchyma of the lung may be silent for a long period and are discovered only accidentally by a routine x-ray examination or by the development of a distant metastasis.

3. When a tumor completely occludes a sizable bronchus the corresponding area of the lung becomes airless and drowned by the imprisoned bronchial secretions. The bronchi become dilated and depending on the type and virulence of the bacterial flora pneumonia or abscess formation results. The physical signs of complete bronchial obstruction must be carefully analyzed as they closely simulate those of a localized pleural effusion. The breath sounds remain vesicular but are faint or totally absent in contrast to the bronchial breath sounds.

characteristically heard when fluid is present there is no egophony. Resonance is impaired and tactile fremitus diminished with atelectasis but usually not to a degree simulating the flatness and absent tactile fremitus of fluid. Signs of a blocked bronchus may be recognized even in the presence of fluid if the breath sounds are faint but vesicular in quality or totally absent. Signs of a closed bronchus are usually an indication for bronchoscopic examination.

4 A tumor of the extreme apical region may manifest itself by invasion of the adjacent structures. The superior sulcus syndrome described by Pancoast is (a) *paralysis of the sympathetic trunk resulting in a Horner's syndrome* (b) invasion of the first dorsal root of the brachial plexus giving pain referred to the arm and partial paralysis of the ulnar and median nerves (c) erosion of the ribs demonstrable usually by x-ray examination. The tumor itself may be visualized with difficulty in the x-ray film in early cases.

5 A primary tumor or metastatic deposit may cause paralysis of the recurrent laryngeal or phrenic nerves on the involved side by direct invasion of the mediastinum.

6 A tumor that incompletely obstructs a large bronchus frequently causes a wheeze noted by the patient and audible as sibilant rales to the examiner. The wheeze may be localized by the patient or the examiner as unilateral thus differentiating it from bronchial asthma. Such a partial obstruction may also cause obstructive emphysema or trapping of the air on expiration in the corresponding area of the lung a phenomenon demonstrable by x-ray films taken in full inspiration and expiration respectively. Recurring attacks of pneumonitis diagnosed as bronchitis or bronchopneumonia punctuate the case history.

7 Ulceration of the bronchial mucous membrane gives rise to the blood streaked sputum or recurrent hemorrhages so characteristic of carcinoma of the lung. This symptom frequently leads to the erroneous diagnosis of pulmonary tuberculosis—a diagnosis that should always be questioned in the absence of a positive sputum.

8 Many tumors undergo central necrosis with cavitation and the establishment of a bronchial fistula. The sputum may be foul

and abundant and often blood streaked. The differentiation between this type of lung abscess and the type uncomplicated by malignant disease may become apparent only at an operation to establish drainage.

9 Irritation of the central portion of the diaphragmatic pleura by extension of a growth gives pain of typical phrenic nerve distribution as the first symptom.

10 Occasionally primary carcinomas of the left lung invade the esophagus producing obstruction or ulceration. The diagnosis may be established by esophagoscopy.

**Diagnosis**—The diagnosis usually depends on the recognition of a suggestive history and physical signs and is confirmed by roentgen ray examination. Although x-ray films may at times establish a definite diagnosis they frequently portray only the pleural effusion or the drowned lung that is produced by the primary tumor. Bronchoscopy may establish a positive diagnosis if a bit of the tumor can be removed for microscopic examination. Many tumors such as 1 2 3 4 5 6 and 9 in figure 486 may not be reached by the bronchoscope so negative evidence by no means excludes the diagnosis. In a large number of cases positive diagnosis by bronchoscopy may be expected in approximately 75 per cent.

**Treatment**—Unless definite evidence of metastasis or inoperable extension of the growth is at hand a patient with a primary carcinoma of the lung should be subjected to open thoracotomy to determine whether the growth can be resected. Treatment by radiation is palliative at best but may be elected as preferable to surgical treatment if the carcinoma is of the oat cell or undifferentiated type and if the likelihood of complete extirpation is minimal. The extent of the opacity in an x-ray film is not a true index of the size of the growth as the shadow may in part be due to the collapsed and consolidated parenchyma of the lung. An artificial pneumothorax at times is an aid in determining operability.

It has been repeatedly demonstrated that an entire lung may be removed with operative recovery of the patient and that single lobes may be removed with immediate palliation of distressing symptoms. Instances of a five or more year arrest of the disease following extirpation are rare but of increasing

frequency. The problem for the immediate future is that of all forms of malignant disease—earlier diagnosis to secure the proper treatment for the patient at a time when the disease is still localized.

The suffering in the terminal stages is often extreme. At times the course of illness is very slow and the patient's life is made miserable for months by severe pain, dyspnea, harassing cough and foul sputum. Uncontrollable hiccoughs, alarming hemorrhages, headache and loss of vision from cerebral metastases may be mentioned as typical of other distressing sequelae that combine to make the patient's existence intolerable.

### METASTATIC TUMORS

Metastatic tumors in the lung are far more common than primary growths and are usually terminal events in a widespread dissemination of the disease. They rarely produce bronchial obstruction or hemoptysis although at times secondary tumors possibly representing metastases to the bronchial walls closely simulate primary carcinoma. Resection of pulmonary metastases is an experimental undertaking but has been proved of life-saving importance in hypernephroma.

### BRONCHIAL ADENOMAS

Circumscribed tumors of undetermined cellular origin are encountered as a cause of partial or complete obstruction of the larger bronchi. These tumors ultimately kill the patient by bronchial obstruction and infection. Hemoptysis is usually an early symptom and may be the only manifestation of the disease over a period of years. If the tumor is pedunculated it may be removed by the bronchocopy but usually the broad base of the tumor and its extrabronchial extension make this impossible. Resection should then be undertaken. These tumors have in the past been mistaken for primary carcinoma of the lung even on microscopic examination of a fragment removed for biopsy. Segregation of this tumor is of extreme importance when dealing with statistics pertaining to primary carcinoma of the lung. Other benign tumors of the lung and bronchi are rare.

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## SURGERY OF PULMONARY TUBERCULOSIS

**General Considerations.**—Tuberculosis is a chronic systemic disease caused by the tubercle bacillus. It has a tendency to heal. General rest and expectant treatment are based on this fact. When pulmonary tuberculosis becomes clinically manifest it is expedient to consider the disease more serious than the symptoms indicate and to institute appropriate treatment promptly. The therapeutic result will be proportionate to the degree and duration of the rest attained.

Rest must be physical, physiologic and psychic. No less important it must be timely. It is much easier to prevent than it is to cure tissue destruction and complications.

The first rational step in the treatment of pulmonary tuberculosis was taken by Detweiler when he adopted Brehmer's idea of the sanatorium and added the principle of systemic rest to conserve vital energy. Rest is and will continue to be, the basis of phthisiotherapy. Additions to the armamentarium can be only supplementary.

James Carson in 1891 was the first to appreciate the favorable effect of pneumothorax and pleural effusion on the diseased lung. He recommended the induction of graded pneumothorax in the treatment of pulmonary tuberculosis to secure local rest of the lung through relaxation. He stated that retraction of cavities by surrounding structures is the greatest barrier to healing. If ever phthisis is to be cured it must be accompanied by mechanical means.

Some sixty years later Potain<sup>1</sup> made similar observations. In 1884 Forlanini, the apostle of artificial pneumothorax, firmly es-

tablished the importance of artificial pneumothorax in order to secure local or physiologic rest

Artificial or induced pneumothorax the second rational step in the treatment of pulmonary tuberculosis has become the most valuable addition to phthisiotherapy. It marks the transition from the passive or expectant regimen to that of active or aggressive collapse therapy.

The benefit of early local rest on the dominant lesions in the lung has been and still is too long deferred. An early pneumothorax is prophylactic; it is more efficient and no greater hazard than later pneumothorax. An efficient pneumothorax cannot always be induced or be continued over a sufficiently prolonged period of time—months or years—to insure success. Delay in the induction of a prophylactic pneumothorax permits conditions to develop within the pleural cavity and lung which will interfere with its later efficiency.

The third and most recent forward step in the treatment of pulmonary tuberculosis is the securing of mechanical relaxation and compression through surgical intervention. Every patient who presents indications for the more radical procedures for surgical collapse is a living example of failure. Failure of the physician to diagnose the case early to appreciate the gravity of the disease and to institute promptly and to continue rigidly the appropriate conservative measures, failure of the patient to cooperate or of the disease to respond to expectant treatment, failure to resort early to the less radical measures for collapse therapy.

Early diagnosis of tuberculosis is not always easy. The very severe forms may be confused with la grippe, influenza and pneumonia. The mild case may simulate a common cold, a recurring or chronic bronchitis. It must be borne in mind how almost universal tuberculous infection is and how commonly it can be activated. It is almost axiomatic that in all pulmonary diseases from the insidious through the very acute to the chronic forms tuberculosis should be considered a probability which should be verified by early and in doubtful cases repeated x-ray examination. If the physician is tuberculosis minded, he will more frequently and much earlier detect its presence at a

stage when the most can be accomplished by medical measures.

Each patient differs in his general and local reaction to infection. The dose and degree of virulence of the infection and the grade of susceptibility which fluctuate from time to time determine the course of the clinical symptoms and the pathologic changes.

The response to therapy likewise varies. Each patient must be treated individually; no inflexible rule can be made to fit all cases. The pulmonary lesions are an accurate index of the trend of battle between the tubercle bacillus and the resistance of its host. The evolution of the local lesion must be as closely followed as is the general progress made by the patient in order to estimate his ability to overcome the disease.

Repeated examination of the chest and lungs checked by periodic x-ray study gives information more valuable than taking the temperature and the pulse.

Early diagnosis, early controlled general rest, early local rest secured by early pneumothorax, early interruption of phrenic nerve conduction and early surgical collapse mean early resolution. There is an optimum time for each form of therapy and a favorable opportunity lost renders general conditions more serious and local lesions intractable.

General rest and expectant treatment should be tried for a reasonable time, a period expressed in terms of weeks. There are many patients whose lesions cannot be controlled by general measures alone or who for economic, social or temperamental reasons cannot be favorably influenced by the usual conservative measures. Should favorable progress fail or cease, measures to secure the additional benefit of local rest exercised by collapse therapy are promptly indicated. "We must obtain promptly the minimum collapse of the lung that is conducive to healing all the tuberculous infiltration and cavitation." The earlier a focus not controlled by expectant treatment is attacked by collapse therapy, the more certain rapid and favorable will be the effect and the fewer will be the complications. Destruction of tissue will be prevented and drastic operations avoided. This is as truly conservative in pulmonary tuberculosis as it is in cancer. Late operations are always of

greater magnitude and danger and the results are more uncertain than with early operations

Surgical treatment cannot eradicate tuberculosis especially in its pulmonary localization. It is not a substitute for but a supplement to accepted procedures when these after a reasonable trial have failed to establish a resistance balance against the disease.<sup>3</sup>

The patient who has not been cured by expectant treatment and who has not had favorable results from artificial pneumothorax or other comparatively minor collapse procedures is a candidate for the more radical forms of surgical collapse. Such a patient is usually in the advanced stages of the disease with vitality depleted, other organs compromised by prolonged toxemia or the tuberculous disease disseminated to other parts. He is psychically depressed when referred for operation as a court of last resort. This all too general tendency to recommend surgical intervention only as a last resort is not giving the patient the best advice; it places an unfair burden on the surgeon and it deters patients with earlier cases requiring operation from availing themselves of its benefits when the conditions are more propitious. Notwithstanding this attitude many persons who would have died have been restored to lives of usefulness. Many more could be more promptly restored if surgical intervention were invoked before the patients become standard risks.

The value of surgical compression therapy is no longer a matter of doubt. It is an incontrovertible fact demonstrated by successes wherever its limitations and possibilities are thoroughly understood.<sup>4</sup>

The purpose of collapse therapy is to prevent the development of restraining mechanical factors or to eliminate the impediments to relaxation and contraction when they have formed.

It is desirable in fact necessary to obtain early and complete closure of all forms of cavities as soon and as safely as possible.<sup>5</sup>

The aim of surgical collapse is to compress cavities and control the interposed lesions which are inimical to the orderly process of healing. The more selective the collapse the less will healthy lung tissue be

impaired; the less embarrassed the respiratory function the more satisfactory the immediate effect and the better the final result. Ablation of a greater mass of lung tissue than is absolutely necessary should be avoided. Surgical collapse is irretrievable. A permanent burden is thrust on the remaining lung which is nearly always or may subsequently become involved to some degree. One can never foresee the demands that may be made on the remaining lung.

A surgeon should approach a case of pulmonary tuberculosis from a medical no less than from a surgical viewpoint. He should collaborate with the radiologist and the phthisiologist who must also become surgically minded. The future of the patient is much safer when he is under the care of men who understand both aspects of his disease.

Before deciding on operative intervention a careful and complete examination of the patient, review of his history and meticulous study of the evolution and the present status of the lesions in the lung so graphically and chronologically recorded by a series of x-ray films are imperative. This information is of inestimable value in deciding what if any surgical treatment is indicated.

General rest lessens the physiologic activity of the lung. The activity of a locally relaxed or compressed lung area is in inverse ratio to the degree of relaxation or compression. With maximum compression the area is in the highest attainable degree of rest. Accumulated secretions in the lobules and bronchioles and exudate in the tissues are expressed and prevented from reaccumulating. Alveoli, smaller bronchi and cavities are made permanently smaller. Aeration is prevented. After the first or expression stage of compression the circulation of blood and lymph in the area is retarded. The absorption of toxins and bacteria is reduced by blocking the avenues of absorption. The blood and lymph stasis laden with toxins incites a progressive fibrosis and an increasing local resistance throughout the area. *Unimpeded fibrosis and only this can and will obliterate cavities and heal the pericavitary lesions.* When the overload has been removed the patient's general resistance is increased and other even distant foci may be benefited or healed. The curve of the clinical symptoms and local pathologic



changes follow each other closely but do not coincide

Man made factors and treatment only modify local and general conditions giving advantage to natural reparative processes

If completion of fibrosis and contraction is interrupted by inadequate or temporary compression the lesions may again become active. The partially compressed and fibrosed cavities may be pulled open or new cavities and foci may form adjacent to the old. Adequate prolonged compression facilitates permanent obliteration and is conducive to healing of cavities and pericavitary lesions. No operation can do more.

For a lasting cure it is obligatory for the patient to continue for months after operation a graded rest regimen. During the first postoperative months the opposite lung in becoming adjusted to the increase in its work undergoes hypertrophy. This may reach 50 per cent above normal.<sup>6</sup>

Increase in physiologic activity on the non operated side may reactivate any of its low grade or dormant foci.

Uneven postoperative stress of the contracting fibrosis on the larger bronchi may cause irregularities of their lumen. A low grade bronchiectasis is developed. This explains in part a persisting morning cough with small amounts of tenacious bacilli free sputum.

Pathologically, following invasion there are four stages of pulmonary tuberculosis: infiltration, destruction, excavation and resolution. These are present in mixed degree and their clinical symptoms therefore can not be sharply classified. Other factors notably allergy, which cannot be so clearly demonstrated have potent influences on the character and severity of the perifocal reaction and the general symptoms.

**Cavitation**—Cavities with their pericavitary lung field present the chief obstacle to recovery and their obliteration is the major problem of collapse therapy.

To classify cases of pulmonary tuberculosis for collapse therapy a distinction may be made between those with and those without cavitation.

Cavitation a complication of pulmonary tuberculosis is generally considered a late manifestation. Cavities may and do form in the early weeks of disease.

The early cavity may be clinically silent. Unless careful and repeated x ray study is made cavities may escape detection until the characteristics of irremediable destruction or chronicity are established.

Cavities form when the balance between tissue destruction and tissue resistance is attained. The formative phase may be considered a conservative process. As long as a cavity remains it is a positive menace. Though a well drained clean cavity is compatible with years of life there is always danger of mixed infection, perifocal spread, intractable pleuritic adhesions, bronchiogenic extension to other parts of the same or to the opposite lung and dissemination via the lymph or blood stream to other organs and tissues of the body. Hemorrhage, severe or repeated, spontaneous pneumothorax, serous to purulent effusion, broncho-pleural fistula or pyopneumothorax may develop.

Cavities are more serious in the exudative than in the fibrotic types of the disease when bronchial drainage is poor and in the younger than in the older patients.

The size, number and location of cavities, the character of their walls, the extent and nature of the reaction in the pericavitary lung field, the presence, character and number of pleuritic adhesions, the firmness or mobility of the mediastinum and the diaphragm, the conformation and rigidity of the chest wall, the efficiency of bronchial drainage and the amount and character of the sputum must be studied before resorting to any form of collapse therapy.

Cavities may be classified as

(a) *Acute* recent progressive walls soft irregular poor or no drainage pericavitary zone of infiltrating edematous exudate.

(b) *Subacute* fluctuating walls soft and thin of indefinite outline enclosing varying amounts of necrotic and devitalized tissue debris exudate and pus irregular drainage the pericavitary zone clearing and showing beginning fibrosis.

(c) *Chronic* stationary well defined thick fibrotic or rigid walls fair to good drainage pericavitary zone of condensing fibrosis.

The character and extent of lesions in the pericavitary zone are of prime importance in the formation, limiting and healing of the

cavity proper. They are of equal importance in determining the form of collapse therapy.

Cavities under favorable conditions may heal spontaneously—by absorption, drainage and contracting fibrosis. The amount and density of fibrosis is the most reliable index of local resistance and a natural tendency to heal. Obliteration is facilitated by compensatory expansion and emphysema of the elastic lung parenchyma surrounding the cavity. These necessary factors are most often present in early and mid lung cavities.

When the anatomic and physiologic limits of contraction are reached further contraction is checked by mechanical factors. Contraction may be prevented by organization of the pericavitary fibrous tissue into dense retracting bands extending into the depths of the lungs to the interlobar fissures or to the hilum where the anatomical arrangement of bronchi, pulmonary vessels and lymphatic structures normally forms a denser area than farther out in the lung.

Multiple cord or band adhesions tethering the cavity, contracting unyielding broad adhesions to the chest wall or diaphragm exert continuous tension on the peripheral area of the lung and any cavity it may contain. This contraction while fairly constant has a tendency to increase as the adhesions become fibrous and stronger. The alternating tug and relaxation exercised by the inspiratory and expiratory excursions of the thoracic wall and diaphragm keep the pleura, the lung, the pericavitary zone and the cavity in a state of irritative activity. This state of unrest is inimical to contraction and healing of the diseased area.

The cavity will migrate or shift in the direction of the strongest pull, i. e. toward the most fixed point.<sup>6</sup> In the upper lung field it will be drawn toward the apex of the thorax where on account of the anatomical relations adhesions are usually diffuse and firm. In the superficial lung field near the visceral pleura adhesions will draw it to the chest wall. In the mid lung area fibrous bands will draw it to the hilum or mediastinum. Near the base it becomes fixed to the diaphragm.

When bands of fibrosis or adhesions extend in nearly opposite directions from the cavity and pull on the walls with almost equal force the cavity becomes suspended

between these two opposing forces. A suspended cavity cannot be healed until one or the other or both restraining factors are relaxed. The contracting fibrosis in a chronically diseased lung which is diffusely adherent to the lateral chest wall draws the adherent mobile mediastinum and its contents toward the diseased side until the limits of contraction are reached.

A progressive or uncontrolled cavity is a surgical condition and demands some form of collapse therapy to secure compression and healing. The principle of collapse therapy by any procedure is the same, the only difference being in technique and degree. The less drastic method should be tried first.

*Suction drainage* of tuberculous cavities is an improved method of direct attack on cavernous lesions.<sup>30</sup>

The rationale of the method includes cleansing the cavity of retained secretions and necrotic debris, leaching the edematous infected cavity wall and pericavitary zone and producing re-expansion and aeration of the immediate pericavitary atelectatic lung tissue by means of negative intracavitary pressure secured through moderate intermittent suction.

The indications for suction drainage are limited: cavities with elastic, thin or non-rigid wall without much infiltration or fibrosis in a pericavitary atelectatic lung field. The cavities must be near the visceral pleura. The overlying pleural space must be obliterated or pleural symphysis must be obtainable. The cavity must be near to and approachable through a related intercostal space.

The cavity proper is not or only partially drained. It is filled with secretion or necrotic debris which can be neither expelled nor absorbed. The inadequately draining bronchi are kinked partially or completely stenosed or obstructed by a check valve cut-off.

The cavity must be accurately located and oriented in relation to the chest wall and intercostal space. Under fluoroscopic guidance a special aspirating needle fitted with a three-way stopcock and graduated so as to indicate the distance the cavity lies from the thoracic wall is introduced through the related intercostal space. One cock is connected with a manometer to check pres-

sure fluctuations of a free pleural space which if present must be obliterated before proceeding and to indicate the entrance of the needle into the cavity. The other cock is connected with a small syringe and some of the contents are aspirated to make certain the cavity has been entered. The direction and depth of the needle are noted. The needle is withdrawn and through the course taken by the needle a trocar cannula with a manometer hook up is introduced to the proper depth in the cavity. Pressure readings are then taken. The mandrin is withdrawn and a snugly fitting catheter is passed through the cannula into the cavity. The cannula is then withdrawn leaving the catheter in place. The next day mild suction is begun and continued intermittently until the catheter extrudes itself or the cavity is shown to have become obliterated by a chronologic series of x-ray films. It may take months before obliteration is secured. The technic is not so difficult as is the proper selection of cases. Suction drainage in a number of properly selected cases has effected dramatic improvement. Unfortunately the improvement is frequently only temporary.

Suction drainage focuses attention on the cavity. It does not take into consideration the pericavitary zone and surrounding area, the common sites for the chief impediment to obliteration of cavities. Cavities treated by suction drainage almost invariably demand supplementary surgical compression by thoracoplasty.

**Collapse Therapy**—Collapse may be accomplished by artificial pneumothorax—unilateral, alternating or simultaneous bilateral.<sup>5</sup> Temporary or permanent interruption of the phrenic nerve and direct or indirect intrapleural pneumonolysis are operations which relax the lung and leave the bony thoracic wall intact. Scaleneotomy, extrapleural pneumonolysis with or without filling the pocket and partial upper partial lower or complete thoracoplasty are operations for compression by altering the bony thoracic wall.

**Artificial Pneumothorax**—Artificial pneumothorax<sup>1</sup> lessens the volume of the lung by the injection of controlled amounts of air through a needle introduced into a free pleural space. It may be relaxing or

mildly compressive. The technic is standardized. There are a few unavoidable hazards connected with the induction and some complications attending the continuance of the treatment. Refills are necessary at more or less regular intervals over a long period of time—sometimes years.

Early continuous moderate relaxing pneumothorax is a prophylactic pneumothorax. It separates the visceral from the parietal pleura, prevents early formation of adhesions, relaxes and rests the lung and is conducive to collapse of early soft thin walled cavities and to the healing of the pericavitary zone and other lesions in the lung. Early pneumothorax may render further measures of collapse therapy unnecessary.

The practice of inducing pneumothorax to rather high degrees of plus pressure in order to secure an increasing degree of compression of the lung or to attempt rapid attenuation of restraining adhesions as desirable as this may be frequently causes even when carefully watched unpleasant or even serious complications. Slow attenuation with low positive pressure is safer though less effective.

**Complications of pneumothorax** are pleural shock, air embolus, serous effusion, tearing of adhesions, rupture of a superficial cavity, hemorrhagic, tuberculous or purulent effusion, pyopneumothorax and pulmonary pleural fistula.

When an efficient pneumothorax is induced and can be continued without lapse for the required length of time, it is the most effective form of collapse. Collapse to be fully effective must completely and continuously relax or compress the predominantly diseased area.

On account of adhesions or obliteration of the pleura a pneumothorax cannot always be induced and maintained to a degree necessary to relax the diseased or cavity bearing area. A patient with a successful pneumothorax may become negligent. Progressive development of advancing adhesions gradually converts an efficient to an inefficient pneumothorax. An incomplete pneumothorax while it may not collapse a cavity does exercise a salubrious effect on the pericavitary area; it renders the pleura less sensitive and the mediastinum more rigid.

and gives the heart and opposite lung time to become somewhat adjusted to the altered intrathoracic pressure. One must not be deceived by this amelioration. In the absence of continuing improvement in the local lesion and collapse of the cavity the patient thus fortified will better tolerate more formidable procedures for collapse. These should be instituted without further delay.

Moderate experience with artificial pneumothorax should enable one to appreciate its value as well as its limitations. Too prolonged treatment without diminution in the size of cavities or continuing improvement of lesions in the lung is not good therapy. It is a waste of a valuable time. It courts complications and withholds from the patient other measures when these give assurance of benefit.

**Intrapleural Pneumonolysis**—*Closed intrapleural pneumonolysis* is the severance of restraining pleuritic adhesions through a thoracoscope by means of an electric cautery or by electric coagulation.

In *open intrapleural pneumonolysis* the pleura is opened and the adhesions are cauterized, coagulated or doubly ligated and cut.

Pleuritic adhesions are the greatest impediment to successful artificial pneumothorax. They may be prevented by early induction. If restraining adhesions are narrow cord, band or fan shape and long enough to permit manipulation of the necessary intrathoracic instruments they may be severed by intrapleural or closed pneumonolysis.<sup>10</sup> Thus may an inefficient or partial pneumothorax be made efficient and complete. Intrapleural pneumonolysis has been improved and made safer and its field broadened.<sup>11</sup>

Exponents of the thoracoscope advocate its use for intrapleural orientation of the size, character, number and length of adhesions.<sup>12</sup>

Adhesions may be thin, thick, short, long, cord, band, broad or fan shape. They may contain attenuated lung tissue or bronchioles with or without tuberculous involvement. Vascularization is superficial or central.

The character of the adhesions and their relation to the tuberculous cavity, lung, pericardium, large vessels (especially at the apex) and thoracic wall are of great impor-

tance not only in the effect they exercise in keeping the cavity and lung expanded but also in the possible danger of puncturing important structures and tearing or erosion of the cavity wall or diseased lung during or subsequent to cautery pneumonolysis.

The type, number and character of adhesions cannot be accurately determined by x-ray study. Their restraining effect must be established before intrapleural severance is undertaken and the reaction it will induce on the diseased area and in the remainder of the lung should be estimated.

In the apex of the thorax, where intrapleural pneumonolysis would be most helpful, it is frequently impossible or too dangerous.<sup>13</sup>

Intrapleural pneumonolysis is an ideal procedure in expert hands for the comparatively few cases in which the operation is indicated.

The complications of intrapleural pneumonolysis are serous to purulent effusion, hemorrhage into the free pleural space, erosion of the lung, pericardium or great vessels, perforation of the cavity, section of parenchymal tissue extending into adhesions, pyopneumothorax and bronchopleural fistula.

**Interruption of Phrenic Nerve Conduction**—Interruption of the conduction of the phrenic nerve was first performed by Stuertz.<sup>14</sup> The exhaustive study of Felix in 1922 established the rationale of the operation.<sup>15</sup> The purpose of interruption of the phrenic nerve is to secure physiologic rest of the lung by paralyzing the corresponding half of the diaphragm.

The effects include paralysis of the diaphragm so that it becomes entirely passive. Any movement it may make and any position it may assume are dependent on the relative intrathoracic tension above as determined by pleuritic adhesions, dense massive or contracting fibrosis of the lung, fluid or air in the pleural space and the influence of the intra-abdominal pressure below the diaphragm. It loses its normal tonus and movement. The piston-like up and down action with each respiratory cycle particularly the inspiratory phase at the base of the lung is stopped. Aspiration and stasis of secretions and pneumonia are prevented. There may be paradoxical movement but

this is of comparatively minor consequence. The diaphragmatic muscle atrophies and unless held by diffuse adhesions in the costo phrenic angle soon begins to rise. Tugging of adhesions and retracting bands of fibrosis extending upward from the base of the lung toward the hilum and apex is relaxed. The average rise is slightly greater on the right than on the left side. The maximum elevation may not be reached for months. The volumetric capacity of the thorax is reduced one sixth (400 cc) or one third (800 cc).

The relaxing effect on lesions in the upper lobe is almost as great as in the lower lobe unless diffuse adhesions interfere. Apical cavities where diffuse adhesions are the rule are not usually affected. Subapical and infracavicular lesions and cavities are more

difficult to treat. The paralyzed diaphragm offers little resistance to the intra abdominal pressure. The unimpeded upward force of the abdominal pressure makes coughing easier and more productive hence less frequent. The diminution of respiratory activity of the lung on the operated side increases the amount of work of the contralateral lung and tests its capacity to assume the burden of respiration.

*The Result*—Interruption of the phrenic nerve produces continuous uniform relaxation of the lung without the inconvenience or dangers of frequent pneumothorax refills. It places the lung in a state of partial rest so that it can improve more rapidly and surely. The time of antituberculous residence is reduced.



Fig. 487—*a* Large thin-walled all-entrant cavity in the right upper lobe. Extensive mixed exudative type of lesions in the middle and right lower lobes. A similar type of lesion in the opposite lung. *b* After phrenic nerve interruption. Marked elevation of right half of diaphragm displacing the heart. Contracting fibrosis of lesions in the middle and lower lobes interferes with drainage of the cavity.

often than not benefited, or healed. Very rarely conditions may be made worse (Fig. 487).

Gaseous interchange within the lung is diminished. The circulation of the blood and lymph is retarded. By this stasis the toxins within and about the lesions are kept more localized. The absorption of air or fluids from within the pleural space may be restricted. This is of importance in artificial pneumothorax. The necessity of refills may become less frequent. Intrapleural tension being reduced adhesions relaxed and the diaphragm elevated the collapsing effect of an equal or lesser volume of introduced air becomes more selective. The danger of com-

Phrenic nerve operations—crushing (phrenic emphysema), cutting (phrenic neurectomy), and avulsion (phrenic excision) because of their simplicity have been abused. They are not and never were intended to be complete or curative operations. Collapse and healing of cavities does occur occasionally. The improvement in both local and general conditions is striking but only too often temporary. Much valuable time and many favorable opportunities are wasted by not taking advantage of this temporary gain to resort to other procedures for collapse.

Paralysis of the phrenic nerve may be temporary or permanent. For temporary paralysis the main phrenic nerve is crushed

and all the access-ory branches are cut. This paralyzes the diaphragm for about three months. The crushing may be repeated so as to continue the paralysis. It is a valuable adjunct to controlled collapse therapy and should be used earlier and more frequently than is now the custom.<sup>16</sup>

For permanent paralysis not less than 4½ or 5 inches of the main trunk of the phrenic nerve must be avulsed from within the

(1) in a case of acute involvement of a lower lobe or mid-lung or a case of acute, diffuse unilateral disease; (2) when there are thin-walled, superficial, basal, mid-lung or infraclavicular cavities with a pericavitary zone of exudative type; (3) when it is desired to obviate the necessity or inconvenience of pneumothorax refills; (4) when pneumothorax is impossible or minimal or the patient is uncooperative; (5) when only

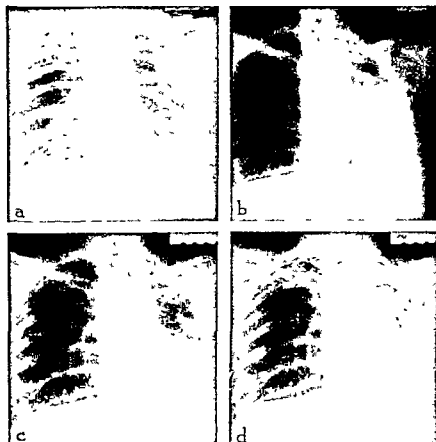


Fig 488—*a*, Extensive bilateral, long-standing fibrosis. There is a large multilocular cavity in the upper lobe of the left lung; *b*, after phrenic extirpation the diaphragm rises markedly and the cavity is smaller; *c*, progressive diminution in the size of the cavity; *d*, the cavity has disappeared. Phrenic nerve interruption was performed as a preliminary to thoracoplasty. The patient improved rapidly and has remained symptom-free for over a year.

thorax. This will usually sever the anastomosis of the accessory branches (present in 20 per cent of cases) which join the main nerve along its course to the diaphragm. Occasionally one or more accessory nerves may have an independent course to the diaphragm. Therefore in doubtful avulsion of the main nerve *c*, all accessories should be cut.

*Indications for phrenic nerve interruption:* Temporary interruption is indicated

an upper stage thoracoplasty or apicolysis is contemplated for resistant lesions of the upper lobe with copious expectoration and a temporary pneumothorax to control the lower lobe is impossible; (6) in case of bilateral disease requiring simultaneous bilateral or alternating compression (a pneumothorax is given on the side of the greater involvement and a crushing of the phrenic nerve is performed on the other side), and

(7) for persistent singultus (accomplished by means of bilateral injection of alcohol into the main nerve)

*Permanent* interruption is indicated (1) as a substitute for or a supplement to pneumothorax especially if partial incomplete or unsatisfactory (2) as a sequence to pneumothorax to taper off the collapse and limit full re expansion of a compressed or fibrotic lung (as much care must be exercised in abandoning as in beginning a pneumothorax (3) supplementary to thoracoplasty in order to increase the compression (4) when the severity of the disease precludes thoracoplasty (5) for severe or repeated hemoptysis not otherwise controlled (6) to relax the lung and favor closing of a pulmonary pleural fistula (7) to reduce the size of empyema cavities (8) to reduce the capacity of the thorax after lobectomy (9) for bronchiectasis of a lower lobe (10) as a palliative measure to relieve severe exhausting painful cough and (11) as a preliminary to operations for diaphragmatic hernia

*Complications* of operations on the phrenic nerve include hemorrhage or air embolus from the tearing of the large veins in the neck or of one of the arteries especially the transverse cervical injury to the thoracic duct mediastinitis resulting from the opening of an infected area or a caseous focus mediastinal hemorrhage emphysema from tearing and adherent lung pericarditis damage to the sympathetic plexus in the neck sectioning other nerves mistaken for the phrenic nerve (the recurrent laryngeal vagus or a branch of the cervical plexus) and prolonged gastric disturbance due to the shifting of the stomach and duodenum

Some authorities state that paralysis of the diaphragm suppresses the physiologic activity in the lower portion of the lung and reduces the respiratory excursions of the lower thorax. The unopposed action of the scalenus and upper intercostal muscles compensates for this inhibition by increasing the activity of the thorax above the fourth rib. If an increase in the transverse diameter and in the excursions of the upper thorax did occur it would unfavorably influence the lesions in the upper lobe.<sup>17</sup>

*Scalenotomy*—Scalenotomy is an operation in which all the scalenus muscles—the

anticus medius and posticus—are severed close to their insertions on the first and second ribs.<sup>18</sup>

The purpose of scalenotomy is to eliminate the action of the scalenus muscles and secondarily to limit the action of the upper intercostal muscles on the upper four ribs.

The effect is conducive to contraction of the upper thorax especially in the transverse diameter and relaxation of the apex of the lung. When the diaphragm is paralyzed the unopposed scalenus muscles tend to overact and cause a compensatory hyperactivity of the upper thorax. A simultaneous scalenotomy or one subsequent to interruption of the phrenic nerve prevents this and augments the relaxing effect of the paralyzed diaphragm.

*The Result*—The degree of contraction of the upper thorax and the relaxation of the apex of the lung are often negligible and disappointing. Some authorities claim that this contraction may amount to 40 per cent.<sup>19</sup>

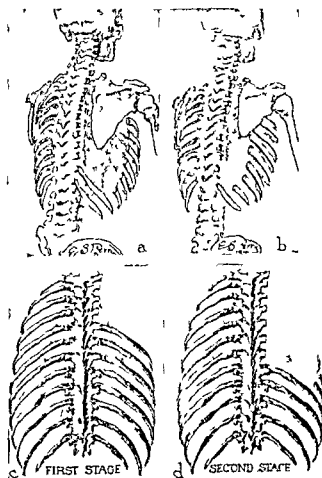
*Extrapleural Pneumonolysis*—Extrapleural pneumonolysis termed apicolysis by Friedrich when limited to the apex of the lung is an open operation by which a cavity and its circumscribing lung area are actively compressed. The endothoracic fascia is separated from the under surface of the thoracic wall overlying the area of the cavity. After the cavity is compressed the resulting subcostal space or pocket is usually filled with some material to maintain the compression.

Extrapleural pneumonolysis is designed to secure a highly selective compression. Were it not for a number of disadvantages it would be ideal. Firm fusion of the endothoracic fascia to the ribs rupture of the cavity or hemorrhage make completion of the operation impossible. The pneumonolysis is not always efficient it is less certain and only slightly if at all less serious than a limited thoracoplasty. No satisfactory filling material has been discovered. Gauze must be replaced frequently fat liquefies muscle atrophies and contracts the amount available is limited and the opening for incision is necessarily large.<sup>20</sup> Air requires refills.<sup>21</sup> A hydrostatic bag requires a projecting tube which invites infection and paraffin is irritating and heavy though recommended by some workers. All of the

material have inherent disadvantages. Introduction of any foreign material leads to irritation, effusion and occasionally the development of infection within the pocket. The material may shrink or shift and the cavity may re-expand. The cavity may undergo pressure necrosis, infect the pocket and discharge externally, causing a bronchial fistula. The filling material may per-

approach its effectiveness in compressing resistant residual cavities especially those in the co-stovertebral groove which a corrective thoracoplasty has failed to close.

*Indications* include small or medium sized chronic fibrotic apical cavities with a pericavitary fibrotic zone, thick overlying pleura, an obliterated pleural space, the remaining portion of the lung being free of dis-





moderate and delayed effects. It is little if any more selective and more prone to complications. postoperative convalescence is slower than after total subperiosteal resection of the upper three ribs.

Extrapleural pneumothorax (subfascial pleurolysis) a subendothoracic fascial space coextensive with the underlying pulmonary area containing the cavity is made by blunt dissection. The space is then kept filled by means of injections of controlled volumes of air. The approach is through an incision in the periosteal bed of the resected (1 or 2 inch segment) rib overlying the cavernous area. The endothoracic fascia is identified and the line of cleavage between it and the

cure and maintain collapse of the cavernous lung area are begun and continued until the cavity closes or the space becomes obliterated. Injections of oil may later be substituted for the injections of air.

Extrapleural pneumothorax is similar to extrapleural pneumonolysis with the exception that only a short segment of one rib is removed. Its advantages are that it is less drastic, less shocking and hence well tolerated. Therefore it may be performed on patients who are very ill or who have bilateral cavitation and could not withstand extrapleural pneumonolysis or multiple stage limited thoracoplasty. The disadvantages are those of incomplete operations: it re-

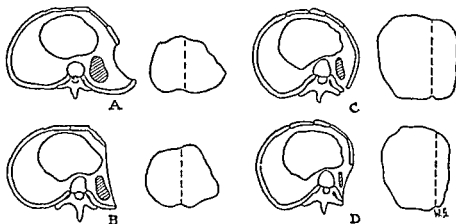


Fig. 490—A Operation of the Seale type in which small segments are resected from the lateral aspect of the thorax. The posterior stumps spring outward a black air and tend to increase the depth and area of the costovertebral groove. B More extensive resection from the posterolateral aspect of the thorax. The shorter posterior stumps still interfere with compression in the costovertebral groove. C Adapted from the original Boivin-Gourlet. Flora of the thorax. A comparatively short segment of the rib is resected. The collapsing effect is much better. D Extensive resection from the transverse space process, almost to the costal cartilage. The costovertebral groove is almost obliterated. The collapse of the lung is very satisfactory.

ribs is carefully followed by blunt dissection working from the under surface of the ribs rather than from the visceral surface to avoid rupture of the cavity or the lung. A subfascial space is made extending widely beyond the known limits of the cavity bearing area of the lung. Absolute hemostasis must be secured by temporary packing with strips of hot moist gauze. The overlying soft parts (periosteum, muscle, fascia and skin) are accurately sutured in layers thus sealing the subfascial space which is then filled with air under low positive pressure. When the wound becomes firmly healed, periodic refills of air manometrically controlled to a moderate degree of positive pressure to se-

quires a prolonged course of air refills; the results are uncertain and there is danger of hemorrhage, immediate operative or delayed rupture of the cavity and intractable or serious infection of the space. It violates a cardinal surgical principle by creating a closed space which may fill with serum or blood. A dead space is prone to infection. It may be performed as a preliminary stage to but not as a substitute for extrapleural pneumonolysis or limited thoracoplasty. Patients are rarely seen who present indications for surgical collapse who conditions give promise of amelioration or cure and who cannot tolerate other procedures for surgical collapse when performed in very

limited stages The advantages are much more theoretical than practical

**Lobectomy**—Lobectomy to eradicate cavity tuberculosis confined to a single lobe has been successfully performed The predominant lesion may be confined to a single lobe It is rarely if ever the only focus Lobectomy is a very formidable operation and the manipulation necessary to free and remove the diseased lobe is fraught with danger of causing widespread dissemination If the remaining lobes are adherent compensatory expansion to fill the intrathoracic space remaining after lobectomy will not be complete The dead space can become a hazard particularly if it becomes infected It must then be obliterated by a thoracoplasty Lobectomy has been performed for the type of cases that have been and can be so successfully treated by the far less drastic operation of limited thoracoplasty

**Thoracoplasty**—Thoracoplasty is the subperiosteal resection of definite lengths of a number of ribs to secure compression of the diseased area and the obliteration of cavitation It may be partial (limited to the upper or to the lower ribs) or complete

Partial thoracoplasty implies the resection of segments from a few ribs complete thoracoplasty implies resection of segments from the first to the eleventh ribs inclusive Complete thoracoplasty in a single stage is most effective and uniform in its compression but the mortality is prohibitive The excessive mortality has led to the performing of multiple stage operations resecting a few ribs in each stage<sup>23</sup> This has reduced the mortality and extended the field of surgical compression to include the greatly debilitated patients

Total or subtotal resection of the upper three or four ribs exercises a remarkably efficient and decidedly selective compression on the upper lobe The lower lobe is not materially affected<sup>4</sup> The collapsing effect of rib resection depends not so much on the length of the segment removed as on the shortness of the remaining stump The number and length of rib segments to be resected are determined by the character extent and localization of the disease in the lung the stability of the mediastinum the thickness of the pleura and the conformation and rigidity of the chest wall Parsi-

monious resection secures only partial collapse and leaves uncollapsed and residual cavities which demand secondary operations Lateral costectomy<sup>23</sup> anterior costectomy or difficult corrective operations Cavities especially those in the costovertebral groove that are not completely compressed by an extensive extrapleural posterior thoracoplasty or by a corrective operation may be obliterated by extrapleural pneumonolysis and gauze tamponade

Extrascapular apicectomy or pneumonolysis first performed by Carl Semb<sup>27</sup> of Oslo secures concentric collapse and contraction of the entire cavity bearing area of the upper part of the lung almost to the level of the hilus In this operation resection of the upper rib segments is not so extensive as in the total subtotal or Alexander type of thoracoplasty The extrascapular ligamentous attachments and adhesions to the lower cervical nerve roots to the large vessels and to the anterior and the posterior mediastinum are carefully severed by sharp and gauze dissection The entire dome of the pleura is freed and then depressed Semb reports collapse of 90 per cent of the cavities with a mortality of 3 per cent<sup>28</sup> Alexander<sup>29</sup> reports 96.5 per cent closures with posterior plus the Haight type of anterior thoracoplasty Overholt<sup>30</sup> shows beautiful plates of the ligamentous attachments and restraining adhesions in describing his technique of mobilization of the lung In practice these are rarely if ever so clearly delineated in the chronic fibrotic cavity bearing lung in which this operation is ideally indicated In these cases the fusion is broad practically continuous throughout the upper lobe Mobilization of the dome of the pleura is best effected by blunt and gauze dissection beginning in the plane along the lower border of the lowest root of the cervical plexus (the eighth) as close to the spine as possible From this point one proceeds forward along the sheath of the subclavian vessels using sharp dissection for the denser bands of tissue The second intercostal muscle bundle is cut close to the spine after ligation of the intercostal vessels The ligament and adhesions to the posterior mediastinum are then severed The adhesions to the anterior mediastinum are then separated Extrascapular pneumonolysis may be performed at the

first upper stage or may be a step in a revision or corrective operation for collapse of resistant cavities. The latter is a more difficult but safer procedure.

With total or subtotal resection of the upper ribs collapse of apical and subapical cavities is more efficient and residual cavities are less frequent than with the resection of the limited segments of the former types of thoracoplasty.

ribbed upper portion of the thorax cannot be adequately supported. On coughing paradoxical expansion of this unsupported lung is inimical to clearing the secretion from the diseased area.

When all efforts to close residual cavities have failed open drainage is indicated. In the early primary selective opening drainage and treatment of cavities no consideration was given to the pericavitary lesions.

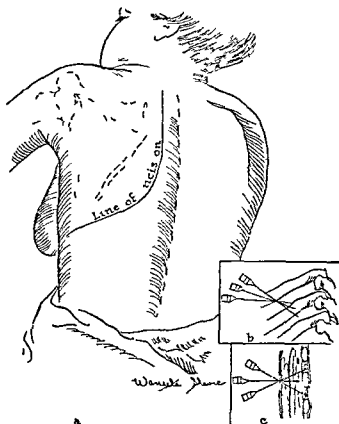


Fig. 491—*a* The patient lies on the operating table with the head low. The arm abducted by an assistant is pulled slightly forward carrying the scapula with it. An incision is made midway between the vertebral border of the scapula and the spinous processes of the vertebral column beginning opposite the spinous process of the second dorsal vertebra. It extends downwards parallel to the spine and then curves around the angle of the scapula almost to the anterior border of the latissimus dorsi muscle. *b* (Adapted from A. Brunner-Tuberculose Bibliothek) Showing direction of the needles for blocking the intercostal nerves. *c* Showing the depth to which the needles are thrust in order to instill the novocain solution into the prefasial space.

Extrascapular pneumonolysis is indicated for apical and subapical cavities with dense fibrotic pericavitary zones without exudative foci.

The manipulation incident to mobilization of the lung is too sudden and massive compression of an actively diseased area of the lung is fraught with the danger of local or widespread dissemination of the tuberculous process. The unsupported mobilized area of the lung beneath the limited de-

and the mechanical impediments to contraction.<sup>23</sup> The results were therefore unsatisfactory. It was noted in cases in which the mass of paraffin had caused erosion and rupture of the cavity wall and infection of the pocket and fistula developed and drained the cavity which then gradually healed. A partially collapsed cavity whose pericavitary zone has been relaxed by previous operations may require open drainage for relief. The periodicity of obstruction to bronchial

drainage the duration and severity of the constitutional toxic symptoms caused by this blocking and the absorption of toxins from the closed cavity must be balanced against the inconvenience of a prolonged and possibly a permanent external fistula.

**Indications for Thoracoplasty**—If the contralateral lung is capable of maintaining the respiratory function then thoracoplasty may be considered. The same general indications obtain as for pneumothorax when this cannot be induced or continued or is unsatisfactory when after a successful

its against mediastinal flutter and cardiac displacement.

Other indications for thoracoplasty include repeated severe bleeding from a cavity that cannot be relieved by other measures, unsuccessful extrapleural pneumolysis, marked fibrosis compressing and embarrassing the heart, empyemas either tuberculous or the mixed infection type which are not controlled by aspiration, irrigation, closed drainage or adequate open drainage, pyopneumothorax with or without bronchial fistula and bronchiectasis. Old

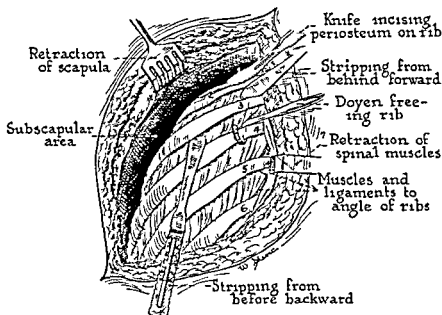


Fig. 492.—Upper stage thoracoplasty. The muscles have been severed. The scapula has been elevated from the ribs and retracted forward and upward. The second to sixth ribs are exposed. The deep-lying first rib overlapped by the second rib cannot be seen until the origin of the serratus anterior muscle has been freed. The periosteum of the second rib is being incised. The intercostal muscles to the third rib are being stripped from behind forward along the upper border and from before backward along the lower border. The Doyen rib stripper is freeing the fourth rib from its periosteal bed. The retraction of the spinal muscles is exposing the neck of the fifth rib with its ligamentous and muscular attachments.

pneumothorax lesions in the re-expanding lung become active or when the lung fails to re-expand after pneumothorax.

Thoracoplasty is indicated if there are predominantly unilateral chronic fibrotic lesions either with or without cavitation and if other forms of therapy and less drastic measures for collapse have been tried and have failed or cannot be expected to succeed. The degree of fibrosis and contraction deformity is a reliable index not only of the local resistance but also of the stability of the mediastinum. A rigid mediastinum gives assurance of cavity collapse and is a secur-

chronic inactive foci or foci of low grade activity with or without cavitation in the contralateral upper lobe near the apex do not constitute contraindications.

**Contraindications**—Active fresh or recent lesions in the opposite lung especially near the base, severe asthma, emphysema, an active or decompensated diseased heart, uncontrolled diabetes and severe disease of the kidneys are absolute contraindications. Tuberculosis in other organs according to the degree of activity is an unfavorable complication which prejudices but does not preclude surgical collapse unless very ex-

tensive. Severe anemia, a low hemoglobin content and a rapid pulse rate are warnings of danger.

The bulk of the patient is in some way associated with the myocardial reserve. The heavy-muscled, soft, fat, flabby, full-chested type of patient gives a deceptive impression of strength but is surprisingly intolerant of surgical intervention. The lean, small-

pressure may give some idea of the myocardial reserve.

Since most of the operative and immediate postoperative and some of the delayed deaths are directly or indirectly associated with a myocardial deficiency, it is of the utmost importance not to overtax the heart. In the absence of any reliable test of the cardiac reserve, one must guard against at-

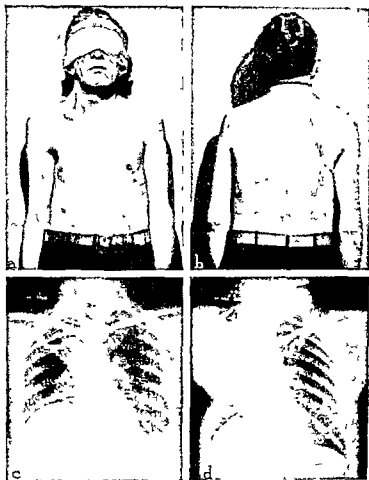


Fig 493—c, Large upper right cavity and activity of the lesion in the lower lobe, controlled by phrenic nerve interruption. There is moderate deformity. The contour of the shoulder posteriorly can be preserved if the incision is not extended so high as b and d. After thoracoplasty in three stages and a corrective operation there is still some activity in the lower lobe that is not controlled by the phrenic nerve and that demands further operative collapse.

chested, light-muscled patient is more tolerant of operations of equal or greater magnitude.

**Dangers of Thoracoplasty.**—The condition of the cardiovascular system, especially the capacity of the myocardium, is one of the most difficult and important factors to estimate. Mild exercise tests, ability to hold the breath, the effect of slow digitalization on the rapidity of the pulse and the blood

tempting too much in any operation. Far better to regret doing too little and have the patient react well than to attempt too much and have the patient die.

The heart is unfavorably influenced postoperatively by (a) shifting with the mediastinum by rotating and sinking in the altered thorax; (b) alteration of the intrathoracic support, especially by the lungs<sup>26</sup> (care must be taken to avoid compressing

the heart by removing too much of the anterior ends of the fourth, fifth and sixth left ribs over the cardiac area); (c) shifting, angulation of and pressure on the great vessels at the base of the heart, especially on

coughing, straining and deep or forced breathing, residual air accumulates in the unsupported area in direct ratio to the force of the expiratory effort of the other lobes and the contralateral lung



Fig 494—*a* Predominant right sided involvement. There is a large multilocular apical cavity and some low grade infection of the lower lobe. Pneumothorax is not possible. *b* After subtotal upper stage thoracoplasty. The entire first rib,  $4\frac{1}{4}$  inches of the second,  $4\frac{1}{2}$  inches of the third and 5 inches of the fourth rib have been removed. The cavity is obliterated, and the lower lobe is clearing. The case is clinically symptomless.

the right side; (d) increase of the resistance in the pulmonary circulation consequent to compression of the pulmonary vessels and loss of the pump action and rhythmic changes in the intrapulmonary pressure; (e) reduction of pulmonary aeration causing dyspnea, anoxemia and general circulatory embarrassment, (f) pleuropericardial adhe-

Secretions accumulate and may be expressed into adjacent lobes or the bronchi of the opposite lung. Atelectasis, spread of infection or pneumonia may develop. Dyspnea, anoxemia, cardiac deficiency, peripheral circulatory paralysis and death may ensue.

To obviate this vicious circle, too extensive de-ribbing must be avoided. The de-



Fig 495—*a* Inadequate collapse after multiple stage thoracoplasty with residual cavities, *b* after a corrective operation through the scar of the original incision. The anterior stumps and the regenerated ribs were removed. The remaining adherent fragments of regenerated ribs are visible.

sions and scars with more or less fixation of the heart, (g) unbalanced volumetric interchange of air between the two lungs, and (h) modification of the extrapleural pressure, especially if too great and precipitate.

The unsupported de-ribbed area cannot participate in normal respiration. During

ribbed area must be supported immediately and for some weeks after operation. Adequate adhesive strapping, leaving the opposite side of the chest free, is necessary. Should respiratory difficulty develop, early inhalation of oxygen or the oxygen tent is indicated.

Shock, intimately associated with cardiovascular embarrassment, is to be guarded against by careful preoperative preparation. During operation too much should not be attempted in any one stage. Hemostasis must be meticulous, the tissues must be handled very gently, and the area must be kept warm, covered and supported by saline packs. After operation the body must be kept warm, the foot of the bed must be elevated on blocks and the patient should be given cardiac stimulation, early oxygen inhalations, dextrose or timely blood transfusions of moderate amounts, repeated as often as indicated.

Some surgeons perform the lower stage operation first. They claim that the over-

The time permitted to elapse between stages varies with the progress of the patient. The shorter the interval, the more uniform will be the compression. A good rule is to allow a sufficient interval for the patient to recover, to permit the heart and the lung to become adjusted to the altered conditions and for the compressed lung area in a measure to clear itself. A first lower stage operation does not produce as great a degree of collapse as a first upper stage operation. If the lower stage is followed too closely by an upper stage operation, the compressing effect of the combined operations may be so great as to cause serious, if not fatal, cardiac or respiratory complications.



Fig 496—*a*, Multilobular cavitation involving the entire upper left lung Pneumothorax which controlled the pencavitary lung fields and improved the general condition of patient, was greatly diminished by progressing adhesions *b*, Upper stage thoracoplasty cavities are greatly reduced Pneumothorax to control the comparatively good condition of the lower lobe is being continued The trachea is displaced to the opposite side *c*, The cavities are obliterated The lower lobe of the lung is allowed to re-expand gradually

flow of secretions into and infection of the uncompressed lung area is thereby minimized, the cough reflex is not greatly inhibited and the cough is more effective. Other equally good surgeons perform the upper stage first for the same reasons.

When the upper stage is performed first, the lower lobe, if free or lightly diseased, may be controlled by a partial pneumothorax, which must be reduced just prior to operation. If a controlling pneumothorax is impossible, a temporary or permanent interruption of the phrenic nerve may be performed. The most logical procedure is to compress the most diseased area at the first operation, thereby securing a greater improvement in the local and general conditions. The disease may be so effectively controlled that unless extension takes place a second stage may not be necessary.

For the very ill patient whose resistance is so low and his reaction to any type of surgical procedure so decidedly poor that the usually well tolerated limited posterior thoracoplasty would be extremely hazardous, Wangenstein<sup>31</sup> recommends multiple stage costectomy.

For the first stage there is an anterior approach through a short transverse incision over the second rib. The pectoral muscles are not cut but are split in the direction of their fibers. The second rib is exposed, and a 3 inch segment is resected subperiosteally, together with its cartilage. If the incision is retracted up and down, anterior segments of the first and third ribs and cartilage may also be removed. There is little bleeding, with very little shock. The wound is closed. A week or ten days later, the second stage is performed. With a posterior approach

through a short oblique paravertebral incision the heavy muscles of the back are split in the direction of their fibers. The posterior ends of the same ribs whose anterior ends were severed in the first stage are cut close to the spine and the entire rib segments are removed subperiosteally from behind. A week or two later the same sequence first an anterior then a posterior stage on the next lower ribs may be repeated three or four ribs being sectioned in each step. This plan a modification of an old empyema operation is excellent but its execution in even better than average hands is far from easy. In the posterior stage the rib must be separated from its periosteal bed on the lateral aspect of the thorax by a modified tunneling procedure.

In old fibrotic cases nature's effort at contraction of the thorax causes the ribs to approximate and occasionally to overlap. Their resection under these circumstances is difficult by the usual posterior paravertebral approach in which the ribs are in full view. With meticulous hemostasis gentle handling of tissues and the avoidance of doing too much at any one stage there will rarely be a patient so ill that he cannot be operated on with reasonable assurance by posterior paravertebral thoracoplasty.

Statistics of different surgeons on the results of surgical treatment are not comparable unless the type extent stage and duration of involvement of the lung and the general condition of the patient are considered. The slower the disease develops the better are the chances for the opposite lung to compensate for the respiratory deficiency and the higher is the grade of resistance. Therefore in the very young and the adolescent patient the disease does not usually warrant surgical procedure. On the other hand in patients over fifty with long standing disease the organs are so compromised by toxins and the effects of the wear and strain of life that they are not often able to withstand a severe operation. Between these decades operation offers in a large group of resistant or advanced cases the only chance of amelioration or cure.

Over 37 per cent of surgically treated patients have been clinically cured 25 per cent have been decidedly improved. The immediate and delayed mortality is approximately 15 per cent.<sup>4</sup>

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## XXIII. THE HEART AND PERICARDIUM

### SURGERY OF THE HEART AND PERICARDIUM

#### COMPRESSION OF THE HEART

**Physiology**—Under normal conditions the heart and the great blood vessels are exposed to a pressure less than that of the atmosphere. This negative pressure within the pericardial and mediastinal cavities is produced by the elastic recoil of the lungs and measures about 5 to 8 cm. of water. The venae cavae and right auricle also carry a negative or sucking pressure. A delicate pressure relation exists between the pressure outside and the pressure inside these venous channels. If the pressure outside the venae cavae and right auricle is increased by a few centimeters of water these structures are temporarily collapsed (Fig. 497). Blood is dammed back in the venous channels until it accumulates sufficient pressure to break through this barrier of pressure from the outside. Then the circulation starts up again and the blood enters and is expelled from the heart. If another increment of pressure is applied to these venous channels the obstruction is repeated and the pressure within the venous channels again must rise to a higher level in order to break through the additional barrier. This play of pressures can continue until the pressure within the venous channels can no longer rise above the pressure from without. When this level is reached the circulation comes to a complete standstill. At all times the pressure within the venae cavae and the right auricle must be higher than the pressure outside these structures. The venous pressure can rise to about 16 cm. of water; this can be considered as the approximate fatal level for intrapericardial or mediastinal pressure developing acutely. If the pressure develops slowly over a period of days or weeks the venous pressure rises to greater heights (42 cm. of water). Such a high venous pressure is a protection against compression of the heart and the great vessels.<sup>1</sup>

**Pathology**—The etiological agent producing acute compression of the heart is always a fluid—either a liquid or a gas. Hemorrhage into the pericardial or mediastinal spaces is the most common cause of acute compression. It occurs when any of the mediastinal structures rupture or when they are penetrated as by a stab wound. Hemorrhage into the pericardial cavity may occur in scurvy and in the hemorrhagic diatheses. Tumors of the heart although rare have a tendency to bleed. The heart is acutely compressed when pus collects in the pericardial cavity. It may be compressed by an exudate or by a sterile effusion. Infections of a gas-forming nature in the pericardial and mediastinal spaces may produce compression. Air escaping from the lungs or trachea may produce pressure on the heart and the great vessels.

Compression of the heart produced by fluid may change from the acute to the chronic form. If the fluid

is in the pericardial cavity the pericardium stretches in response to the long-continued tension. The fluid may be walled off and localized either inside or outside the pericardium. Rheumatic fever and tuberculosis are most commonly associated with the formation of fluid but any pyogenic organism may be present. After a time a less virulent infection may spontaneously become quiescent, and the fluid may disappear. Residual signs of such an infection consist of adhesions and scar tissues. Bands or sheets of scar tissue gradually increase in density and like scars anywhere in the body undergo contracture. Such a scar may compress the entire heart or it may produce local compression.

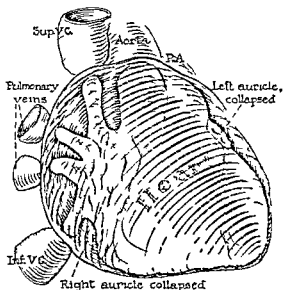


Fig. 497—The heart is compressed by fluid in the pericardial cavity. It is smaller than normal. Note the collapse of the intrapericardial segments of the venae cavae and the right auricle. The venous channels outside the pericardium are distended.

over the venae cavae, right auricle, right ventricle, left ventricle or pulmonary artery (Fig. 500).<sup>2</sup> Calcium may be deposited in the scar. Curiously enough the adhesions and scars following rheumatic fever do not produce compression of the heart.

The compressed heart is a small, shrunken organ. It cannot dilate. It cannot undergo hypertrophy. It receives a subnormal quota of blood and it performs a subnormal quota of work. It can do nothing about this reduction in work load. It receives and it pumps out whatever blood is delivered to it. As the work load of the heart is reduced, the cardiac muscle undergoes atrophy. It undergoes diffuse atrophy in exactly the same way as does any other muscle in the body when it is not allowed to perform its full normal function. After compression has been relieved, some time is required for the cardiac muscle to regain its normal

strength. In a patient with long-standing compression six months to a year may be required for the heart to regain its normal strength.

The compressed heart is a quiet heart. The precordium shows little or no pulsation. The presence of a

of the heart simple and infallible (Fig 500). The acute compression triad consists of (1) a rising venous pressure, (2) a falling arterial pressure and (3) a small quiet heart.

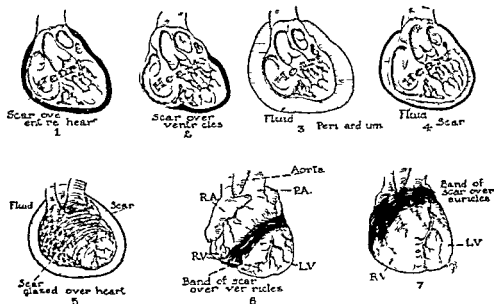


Fig 498—Various anatomical conditions that produce elevated intrapericardial pressure. Each of these conditions can produce the so-called Beck syndrome.

well marked pulsation or heave in a patient with circulatory failure points to a dilated hypertrophic heart and never to a compressed heart. Under the fluoroscope the lastole-systolic expansion of the heart is visibly reduced. The pulsation may be entirely absent. One

(Fig 500 B). As the heart and venae cavae are compressed the filling of the heart is disturbed and the pressure in the venous system rises. The rise in venous pressure

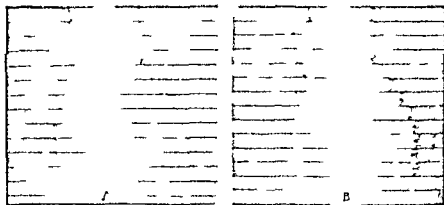


Fig 499—Artistic sketches (actual tracings) from kymograph roentgenograms of the heart. The depth of the serrations in the outline of the heart indicates the amplitude of the pulsations. A: The heart compressed by scar before operation. The pulsation is greatly reduced. B: The same heart after resection of the compression scar. The pulsation is greatly improved.

ventricle may pulsate less than the other. A permanent record can be made by means of the kymograph roentgenogram (Fig 499).

**Diagnosis.**—The Beck triad makes the diagnosis of acute and chronic compression

and the rise in the pressure exerted on the heart and cavae must run parallel. They can go up to almost 16 cm. of water before death occurs. The veins are not prominent because their walls have not had time to

stretch. Similarly the liver is not enlarged. As the flow of blood into the heart is reduced the output obviously is reduced by the same amount. The pulse weakens and signs of arterial failure appear. The patient at first shows anxiety and later unconsciousness from cerebral anoxemia. The skin becomes pale and cool. The heart is quiet. Pre-

it can be demonstrated roentgenographically. Pulsus paradoxus is present.

The chronic compression triad consists of (1) ascites, (2) a high venous pressure and (3) a small quiet heart (Fig 500 C). Ascites is one of the most conspicuous features in the severe form of compression. One patient calculated that he had had almost a

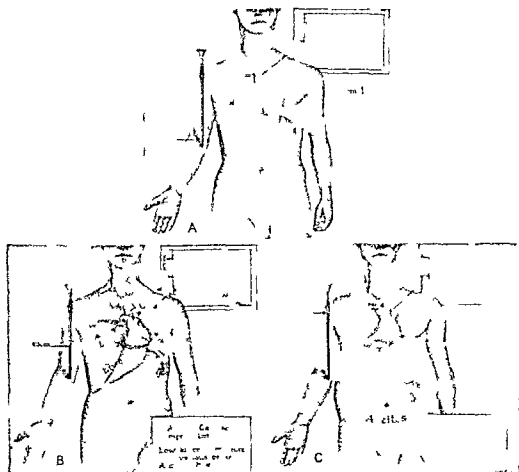


Fig 500.—Cardiac compression triad. For comparison normal (A) acute (B) and chronic (C). The acute compression is produced by fluid in the pericardial cavity. Note collapse of the venous gateway and distention of the veins outside the pericardium. The ventricles are shrunken and the heart *per se* is smaller than normal. The parietal pericardium has not had time to dilate nor has there been sufficient time for the liver to enlarge and for ascites to form. In the illustration for chronic compression of the heart the compression is produced by scar tissue. The heart is a small shrunken organ in contrast to that in cardiac dilatation. The veins dilate in response to the high venous pressure. The liver and spleen enlarge and ascites develops.

cordial pulsation is reduced or absent. The cardiac sounds are distant and faint. The area of cardiopericardial dullness is increased but in acute conditions the increase in size is slight and it is not worth delaying an urgent operation to obtain a roentgenogram. In a less acute condition the pericardium has time to stretch and the amount of fluid around the heart increases so that

ton of fluid removed from his abdomen over a period of four or five years. The ascitic fluid is a sterile straw-colored transudate. The venous pressure can rise to 42 cm of water. The walls of the veins stretch and become tortuous standing out like goose quills. The smaller veins also are distended and cyanosis is present. The liver and spleen en-

large and sometimes are covered by a layer of fibrous tissue and exudate. The cardiac sounds are distant and faint. The heart itself becomes a small shrunken organ. It is generally taught that the heart enlarges and undergoes hypertrophy in this condition. This is a fallacy. The compression agent makes it impossible for the heart to dilate or to undergo hypertrophy. While the heart is small the fluid or the scar compressing it

pulse pressure is narrowed and usually measures 20 mm Hg. The systolic pressure is about 100 mm Hg. The pulse is paradoxical.

**Purulent Pericarditis**—As a rule the diagnosis is established by the presence of fever together with signs of acute and chronic compression of the heart. The roentgenogram shows evidence of fluid in the pericardial cavity. **Purulent pericarditis**

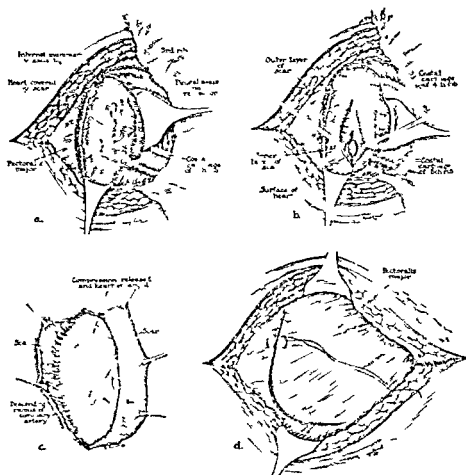


Fig. 301.—Steps in the resection of a compression scar: a transverse incision on the fourth and fifth costal cartilages removed; the internal mammary vessels ligated; the mediastinum opened and the pleural space dissected to the left; b dissection in the compression scar which has two layers, the epicardial surface being shown; c resection of scar from the heart; d the pectoral muscle is replaced and closure is being started.

may give a large area of percussion dullness or a large roentgenographic shadow. It may or may not be fixed in position. Fixation of the heart by extrapericardial adhesions is of no significance with regard to either diagnosis or treatment. The electrocardiogram shows slurring and low voltage. Dyspnea on exertion, malnutrition, weakness, hydrothorax and subcutaneous edema are other manifestations of chronic compression. The

should be suspected in a patient who has an infection such as pneumonia or osteomyelitis and who is not improving satisfactorily. The diagnosis is confirmed by aspiration of pus from the pericardial cavity. If the pus is tuberculous repeated aspiration is required. In cases of non-tuberculous infection pericardiostomy is the only method of treatment. The operation consists of removal of the fifth left costal cartilage and suture of

the pericardium to the skin. A more extensive operation is not necessary. Irrigation with Dakin's solution or any strong antiseptic is contraindicated because such solutions erode the surface capillaries, resulting in the formation of scar tissue.<sup>3</sup>

**Compression Scars.**<sup>4</sup>—Chronic compression due to the contracture of scar tissue is designated by a confusing nomenclature, which includes such terms as adhesive pericarditis, mediastinopericarditis, Pick's disease, Concato's disease and polyserositis. Adhesions play absolutely no part in this disease. The diagnosis can be made with great simplicity and accuracy. The treat-

#### ADHESIONS TO THE HEART; ANGULATION AND TORSION OF THE HEART

It is generally believed that adhesions disturb the action of the heart and that they can produce dilatation, hypertrophy and failure.<sup>5</sup> The relationship between adhesions, on one hand, and dilatation, hypertrophy and failure of the heart, on the other hand, has been generally considered as one of cause and effect. On the assumption that the heart wastes energy in pulling on the chest wall through adhesions, attempts have been made to correct this condition by operation. There are two possible ways of obtaining correction. One is to sever the central end of the

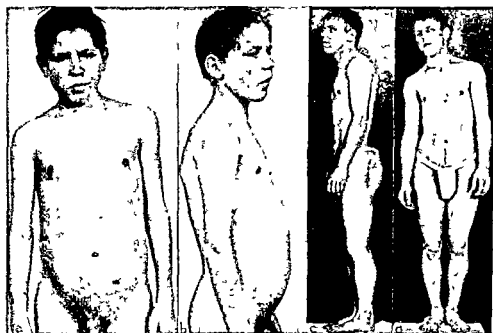


Fig. 502.—a and b, Chronic cardiac compression due to generalized epicardial and pericardial scar. Note the ascites and anxious expression. A bedridden cardiac invalid. c and d, Six years later, cured.

ment is surgical (Fig. 501). The scar is resected from the anterior and lateral aspects of the heart. The left side is resected before the right side. If the pulmonary artery or the venae cavae are compressed, these structures should be freed. The operation should be done after the patient becomes afebrile, sometimes months of rest in bed being necessary. In certain cases of tuberculous scar formation the waterlogging is so pronounced and rapid that resection must be done even though the infection in the scar shows activity. The results of the operation are excellent. Complete and permanent cure can be obtained (Fig. 502).

adhesions i.e., the cardiac end. The other is to relax the particular part of the chest wall that is pulled on by removing the bony framework, ribs and sternum from that region. The first alternative was not utilized, but in 1902 the second idea was applied, and the Brauer operation came into use, being incorrectly called cardiolytic.<sup>6</sup> The patients selected for the operation were those who had heart disease and adhesions and who showed various stages of dilatation, hypertrophy and failure of the heart. Most of them had rheumatic heart disease with a precordial heave, retraction of the chest wall and Broadbent's sign. Reasonable as it ap-

pears this theory has not met with satisfactory laboratory support. Also a critical analysis of the autopsy material of human hearts with adhesions does not support the idea that adhesions lead to dilatation, hypertrophy and failure of the heart. It can also be stated that a critical analysis of the results obtained by this operation shows that the operation is not clearly and definitely beneficial.

Adhesions can produce angulation and torsion of the heart. These displacements can produce symptoms by interfering with cardiac filling. Attacks of tachycardia and syncope may appear. Section of the adhesions, paralysis of the diaphragm and thoracoplasty give beneficial results. Such cases of dislocation of the heart require treatment by operation. Disturbances of the circulation produced by angulation and torsion of the heart are not to be confused with the energy loss theory of pulling on adhesions.

#### DECOMPRESSION FOR CARDIAC HYPERTROPHY

The heart occupies practically all the space between the vertebrae and the sternum. On the assumption that this space is inadequate for the heart after it has undergone dilatation and hypertrophy, Morrison<sup>7</sup> in 1908 proposed an operation which might be called a decompression for such a large heart without adhesions. The operation consists of the removal of precordial ribs, cartilages and sternum. In young patients the precordium will bulge forward freely to accommodate an enlarged heart, but later on when the chest wall becomes less pliable this forward bulge does not occur. It is difficult to say how much benefit this operation gives to a dilated hypertrophic heart.

#### TRAUMA

**Penetrating Wounds of the Heart and Intrapericardial Segments of the Great Vessels<sup>8</sup>**—These are stab wounds or gun shot wounds. The wound of entrance is usually over the precordium, but it may be elsewhere—in the neck, abdomen, buttock or esophagus. It may bleed and suck in air. Signs of acute compression establish the diagnosis. The escape of blood into the pericardial cavity may be rapid or slow. The wound may enter the myocardium at an

acute angle, in this event there may be little or no hemorrhage. Such a wound may recover spontaneously. Most wounds of the heart and intrapericardial segments of the aorta, pulmonary artery and venae cavae require urgent operation. The method of handling a ventricular wound is illustrated in figure 503. Ventricular muscle should never be taken in hemostats. The margin of an auricular wound, however, should be grasped in hemostats. The two margins of the auricular wound are brought together in the hemostats and the bleeding immediately ceases. Sutures are then placed and the clamps are removed. Bleeding from an auricle cannot be stopped by placing a finger on the wound. A large penetrating wound of the ventricle is rapidly fatal. If the blood escapes freely from the pericardial cavity exsanguination takes place. If the blood does not escape, compression rapidly develops.

A foreign body in the pericardial cavity or in the myocardium should be removed as soon as is feasible after the accident. If the patient is seen late the foreign body should be removed if possible because of the danger of cardiac rupture or the development of an embolus if the foreign body should work its way into the cavity of the heart. Sometimes the foreign body is securely fixed by scar tissue so that it cannot migrate. Exploration is advisable.

**Non Penetrating Wounds, Contusions of the Heart<sup>2</sup>**—Overlooked clinically and neglected surgically, the contusion is the most common form of cardiac trauma. The steering wheel injury is the classic and most common method of infliction (Fig. 504). Any severe blow over the precordium may produce contusion of the heart. The ribs and sternum need not be broken. A forceful localized impact over the precordium like the blow from a golf ball may produce contusion of the heart.

The signs and symptoms vary greatly. In most cases contusion of the heart produces no serious symptoms and is not recognized. Weakness is the most important symptom. It may appear immediately after the injury or it may not appear for several days. Usually weakness will disappear in a few minutes, hours, days or weeks, but occasionally it is a permanent symptom. A fall in blood

pressure occurs but as a rule this is transient and lasts but a few minutes. Pain is usually present. It is precordial and may go down the arm, as does anginal pain. Tachycardia is the rule and persists for minutes, days or years. Auricular fibrillation occurred in one of my patients, was permanent and did not respond to drugs. Brachycardia is rare. Electrocardiographic changes usually but not always occur. Changes in the T and deep Q waves are found. The tracings should be repeated daily in cases in which contusion is suspected. The alterations from normal usually, but not always, appear early and disappear within a few months. The changes in the electrocardiogram are to be differentiated from those occurring with

the purpose of preventing rupture or the formation of an aneurysm of the heart.

After the diagnosis of contusion of the heart has been made, the patient is kept at complete rest. If the condition is serious he is moved to the operating room for observation so that operation can be carried out immediately when definite indications appear. Morphine is administered. Quinidine is used to prevent ventricular fibrillation and to slow the rate. If rupture occurs, operation is indicated. If rupture does not occur, the patient is treated as though he had coronary thrombosis. He is kept in bed six weeks. It has been found that if the patient survives the first nine hours, his chances of surviving the first week are better than his chances of



Fig 503—Method of suturing a wound of the ventricle. A suture is placed in the apex so that the heart can be steadied and the finger can be held on the wound. Control sutures are crossed, the finger being removed, and the wound is sutured. The finger should not be inserted into the wound.

coronary thrombosis. Dyspnea on exertion and cyanosis are other symptoms.

Recovery is the rule. Death is the exception. It is amazing the amount of trauma that the heart can tolerate. Death may occur from ventricular stand-still, from ventricular fibrillation or from cardiac rupture. Cardiac rupture is amenable to surgical intervention. A rupture of the auricle or ventricle can be sutured, although this operation has never been performed up to the present time in a case of non-penetrating injury. The patient should be continuously watched for signs of acute compression so that the operation can be performed before the heart permanently stops. I have described the method of applying free graft of pericardium or fascia lata to reinforce the contusion for

surviving the second week. Delaying hemorrhage may occur, and when it does, the treatment is operative. Pericardial effusion may appear and can be aspirated. Up to the present, surgical aid has been given to only two patients, one was treated by Mansell Moullin for the removal of bloody fluid from the pericardium and the other patient I operated on for ventricular fibrillation, which occurred as a terminal development. This patient had a mural thrombus in each ventricle.

Other forms of non-penetrating trauma to the heart occur. The heart may tear away from the aorta when the body falls from a high building. Compression of the legs and abdomen may drive the blood forcibly into the heart and rupture the right auricle. This

occurs in cave-in accidents Straining may rupture an auricle Indeed an auricle can rupture spontaneously Direct trauma to the chest may rupture the heart, any of the valves or a papillary muscle I saw one patient whose ventricles were strangulated through an opening in the parietal pericardium Some of these conditions can be treated by operation

Certain injuries to the upper portion of the abdomen such as those produced when a wheel passes over the body or when a horse rolls on the body result in rupture of the diaphragm and circulatory shock In these cases the shock has always been ascribed to rupture of the diaphragm but this

of movement disappears Each of these means death unless a coordinated contraction is restored to the heart In the vast majority of cases attempts at restoration are futile A myocardium poisoned by bacterial toxins or weakened by chronic disease cannot be made to function but a patient whose heart stops suddenly sometimes can be saved for instance a patient whose heart stops suddenly in the operating room as a result of anesthesia hemorrhage, respiratory paralysis, status lymphaticus electrocution from cauterizing vagus inhibition pneumothorax asphyxiation or cardiac trauma

The first requirement in restoration of the heart beat is aeration of the lungs Success

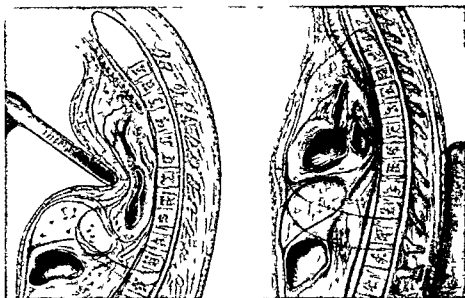


Fig 304—The steering wheel accident an injury that will become a classic type always to be associated with contusion of the heart \*

is a fallacious idea Tearing of the diaphragm does not produce circulatory shock The cause of the shock is the accompanying contusion of the heart The presence of cardiac contusion should be taken into consideration in deciding on the treatment to be given the diaphragmatic rupture Ventricular fibrillation is a threat to an early ill-planned operation on the diaphragm

#### RESTORATION OF THE HEART BEAT

When the pumping action of the heart ceases and the arterial pressure disappears the ventricles either come to a complete standstill or go into incoordinated fibrillary twitchings for a while before every vestige

is impossible if the myocardium is evanescant Also the brain cannot tolerate anoxemia Aeration of the lungs is carried out either by forcing air and oxygen into an intratracheal tube or by mechanical compression of the chest Intratracheal insufflation is more effective and should be used whenever possible The patient must be kept warm

**Ventricular Standstill**—One cubic centimeter of 1 to 1,000 solution of epinephrine diluted with a few cubic centimeters of saline solution is injected into the left ventricle or cardiac muscle through the chest wall Massage is carried out through the chest wall If the heart does not begin to



pulsate almost immediately, the chest is opened and the heart is directly massaged forty to fifty times per minute. Aeration through an intratracheal tube is being given at the same time. If the heart does not start, a similar quantity of epinephrine is dripped on the surface of the heart or is injected into the right ventricular cavity. Massage is continued. Too much epinephrine will throw the ventricles into fibrillation. Manual massage should be continued because it can keep all the tissues viable and the beat can be restored if the muscle has not been irreparably damaged.

**Ventricular Fibrillation.**<sup>10 11</sup>—If the ventricles fibrillate, restoration of the coordinated beat is impossible until the fibrillary

will send the ventricles into fibrillation, but it is difficult to cause fibrillation after procaine or metycaine has been used. It is needless to say that perfect aeration of the lungs is given throughout the entire procedure. The human heart was defibrillated for the first time on Dec. 7, 1938.

### TUMORS OF THE HEART AND PERICARDIUM

The heart, like other organs in the body, may be the seat of tumor formation, but this occurs rarely. Most of these tumors are metastatic, but a few are benign and operable. In one of our cases an intrapericardial dermoid produced pressure upon the right side of the heart, and it was completely and

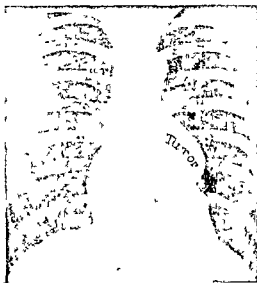
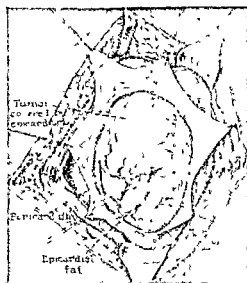


Fig 505—Benign tumor of the left ventricular wall successfully removed at operation

movements disappear. This is accomplished by the use of procaine or metycaine on the heart. Two cubic centimeters of 5 per cent solution of procaine is dripped on the surface of the heart or injected into the right ventricular cavity. Massage is carried out continuously to maintain the circulation and to prevent dilatation of the heart. Success cannot be achieved if the heart is dilated. Two large electrodes are placed on the ventricles, and an alternating current of 1 to 15 amperes is sent through the heart for one-half to about two seconds. This sends all the fibers into contraction at the same time, and uniform relaxation follows. The heart is then at a standstill. Massage and epinephrine are used next. Too much epinephrine

successfully removed. Figure 505 shows a tumor in the wall of the left ventricle, which produced pain and dyspnea and which was completely and successfully removed. It had a calcified shell which contained putty-like material rich in fat. The patient was relieved of his symptoms.

### PATENT DUCTUS ARTERIOSUS

The ductus arteriosus is an essential part of the circulation in fetal life. Its function is lost after birth, and normally the duct becomes obliterated. Obliteration is complete in 95 per cent of children at the age of twelve weeks and in 98.8 per cent at the age of one year.<sup>12</sup> Blood passes through this structure as long as it remains patent, be-

cause normally a differential pressure exists between the aorta and the pulmonary artery (Fig 506). As long as the pressure in the aorta is greater than the pressure in the pulmonary artery the flow is from the aorta into the pulmonary artery. Cyanosis there

ventricle.<sup>12</sup> It is obvious that this leak should affect the health of the patient. A small percentage of the patients tolerate the leak quite well but it is a constant drain upon the circulation. It is a factor in the development of endocarditis, endarteritis, heart fail

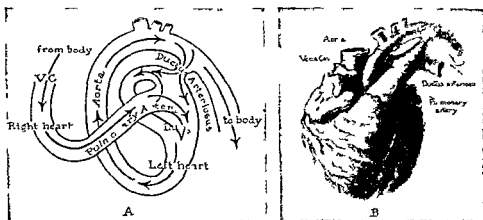


Fig 506—A Diagram of circulation showing the short circuit of blood through the patent ductus arteriosus. B Heart of a three-day-old child illustrating patent ductus arteriosus. (Hofman and Beck.)

fore is not present. When the left ventricle fails the flow may be reversed and cyanosis may appear.

The ejection of blood from the aorta through the ductus into the pulmonary artery is forceful and produces a vibration or thrill similar to that of an arteriovenous

ure and pulmonary infections. These complications are the cause of death in almost 80 per cent of the cases.<sup>14</sup>

**Diagnosis.**—A correct diagnosis can be made in almost every case. Weakness, shortness of breath, and fatigue on exertion are the usual symptoms. The patient may be un

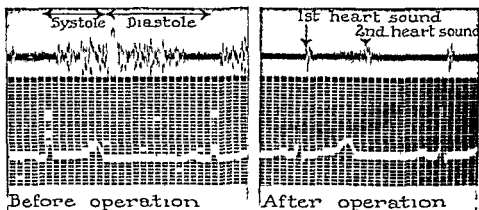


Fig 507—Phonocardiogram and electrocardiogram (lead 2) of a patient with patent ductus arteriosus. Note murmur during both systole and diastole also disappearance of the murmur after ligation of the ductus.

fistula. The alterations in the physiology of the circulation are precisely similar to those produced by an interventricular leak and consist of an increase in the circulating blood volume, a lowering of the diastolic arterial pressure, and dilatation and hypertrophy of the heart, especially of the left

ventricle. Cyanosis is not present as long as the heart is compensated. The patient may be subject to frequent pulmonary infections.

The thrill and the murmur are the most important diagnostic aids. The thrill is produced by the leak and is felt in the second

or third intercostal space to the left of the sternum. The patient or the mother may be aware of a noise in the chest. The thrill may be continuous, with accentuation during either systole or diastole. The murmur is loud and machine-like and is systolic and diastolic (Fig. 507). Exercise may be necessary to bring out the diastolic component. The murmur is loudest in the region of the thrill and may be faintly heard over the apex. It may also be heard in the neck and between the scapulae. The systolic arterial pressure is normal, while the diastolic ar-

are cut across, and the pleural and mediastinal cavities are opened. Mechanical respiration should be used during the operation.<sup>16</sup> Figure 508 indicates the anatomical structures encountered in the operation.

Recently the operation has been applied to patients with bacterial endarteritis. One of these patients was cured of the blood stream infection after the operation.<sup>17</sup> In the presence of endarteritis there is an extra hazard to the operation, consisting of a greater likelihood of tearing either the aorta or pulmonary artery or the duct

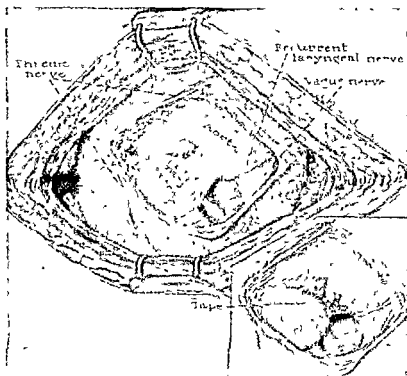


Fig 508.—Patent ductus arteriosus. Inset shows the structure ligated with tape. Recurrent laryngeal, vagus and phrenic nerves are shown.

terial pressure is less than normal. The pulse pressure is increased. The heart may not be enlarged.

**Treatment.**—The treatment of this condition consists of ligation of the ductus whenever possible.<sup>17</sup> In some cases the opening consists of a fistula between the aorta and the pulmonary artery, and closure of the fistula by a ligature is technically impossible. If the duct can be isolated without too much risk in the dissection, it should be ligated with tape. The approach is through an incision between the second and third ribs. The second and third costal cartilages

Cardiologists do not agree concerning the indications for operation in this condition, but it seems to me that there is little room for argument. The duct should be ligated in every condition if this can be safely done. With good mechanical respiration the hazard of the operation should be very slight.<sup>10</sup>

#### ESTABLISHMENT OF A NEW BLOOD SUPPLY TO THE HEART BY OPERATION

**Anatomical and Experimental Considerations.**—The circulation in the heart muscle can be altered by operative methods, and these alterations can protect the heart against the ravages of coronary artery

disease Protection against coronary artery occlusion can be given in two ways (1) by the establishment of an extracoronary vascular bed and (2) by the establishment of communications between the three major coronary arteries The extracoronary vascular bed is produced by grafting vascularized tissues upon the surface of the heart The tissues available for grafting are parietal pericardium mediastinal fat skeletal muscle from the chest wall and omentum brought up through an opening in the diaphragm Communications between the coronary arteries and the arteries of the grafts have been demonstrated by experiment<sup>18</sup> This grafting operation is made possible because the heart has a free surface on which grafts can be placed The production of intercoronary communications has been demonstrated by experiment<sup>19</sup> They can be produced by two methods one of these being occlusion of a coronary artery If one of the major arteries is occluded and if the animal survives the occlusion then the three major arteries become anastomosed A retrograde flow develops into the occluded artery from the other arteries and after a period of weeks or months a good blood flow is produced to that part of the myocardium that was supplied by the occluded vessel It is obvious that this stimulus to the development of intercoronary communications cannot be utilized as a therapeutic measure However nature does utilize it in the presence of coronary artery disease As coronary sclerosis develops in the human heart intercoronary communications develop and protect the heart against the disease In many instances the improved circulation is such that death is averted until two or more of the major vessels become occluded<sup>20</sup> Indirectly it can be shown that this stimulus can be utilized by operative methods There are two destructive factors which appear as a major coronary artery becomes occluded One of these is an increase in the irritability of the anoxic muscle so that the ventricles lose their coordinated rhythm and go into fibrillation This is fatal The other factor produced by occlusion is death of myocardium from lack of oxygen Muscle deprived of its blood supply is changed to scar tissue and this alteration is irreversible Both of these destructive factors can be held in abeyance by a relatively small amount of blood supplied to the occluded artery If the heart can survive the crisis produced by occlusion so that ventricular fibrillation does not appear and the myocardium does not die then reparation is possible The occlusive stimulus has time to express itself The circulation improves and these threatening factors disappear The coronary arteries are now joined together This relatively small amount of blood required to keep the muscle viable and to prevent fibrillation can be given to the occluded artery by operative methods<sup>19</sup>

The other method by which intercoronary communications can be produced is by means of inflammation This is a surgical method The inflammatory agent can be either chemical or physical A special study of this subject has been carried out<sup>21</sup> and it has been found that calcium and magnesium silicate applied to the surface of the heart in small quantities produces the most favorable result Many chemical agents produce a severe reaction and are dangerous It has also been found that abrasion of the surface of the heart

without the use of chemical irritants or grafts opens up intercoronary channels<sup>19</sup> Abrasion alone can reduce the mortality produced by coronary artery occlusion and it also can reduce or entirely prevent the formation of an infarct after a major coronary artery has been ligated

The presence of a common coronary bed affords protection to the heart in the presence of coronary arteriosclerosis Conversely, the absence of such communications makes the heart vulnerable to occlusions The communications between coronary arteries vary in different normal hearts In some they are practically absent in others communications are present but they are never very pronounced

**The Beck Operation for Coronary Artery Disease**—This operation was devised for the purpose of improving the circulation to the heart muscle Grafts were placed upon the heart the surface of the heart was abraded and powdered beef bone was placed upon the abraded surface to produce an inflammatory reaction The tissues used for grafting purposes consisted of parietal pericardium mediastinal fat and skeletal muscle from the chest wall This operation was performed on a group of thirty patients<sup>22</sup> The results in general have been favorable and in some of the cases have been almost incredibly beneficial Although all of the patients were totally incapacitated before operation many of them were able to return to work after operation

Certain premises should be borne in mind in reference to this operation The operation does not eradicate the disease and complete cure is not to be expected One must think in terms of improvement rather than of cure One must accept the conclusion that a scar in the myocardium remains a scar it can not be changed back to myocardium It is to be expected also that certain patients may not appear to be helped by the operation because the destructive process of the disease may be more rapid than the reconstructive process following the operation Also in one type of disease the benefit from the operation may not be very great This is the type in which all the major coronary arteries undergo a similar degree of occlusion In this type of disease the anoxemia of the heart muscle is generalized and the requirement for cure consists of an outside blood supply of large proportions The blood vessels in the grafts are large enough to be easily seen in cleared specimens Whether they can become a complete and adequate substitution for the coronary arteries remains to be determined but this is an almost unreasonable expectation It is implied that the greatest benefit is to be expected in those cases in which localized anoxemia is present

After doing the operation on a study group of thirty patients it was decided not to do it on a tidal patients until more data were obtained Six years have elapsed since the last operation was done Recently we have taken up the operation again it will be tested and the results measured If these preliminary tests are satisfactory the operation will be ready for application

We used omentum in some of our early experiments carried out in 1932 and we were able to demonstrate anastomoses in these grafts We have not used this procedure on patients but O'Shaughnessy has done so

with beneficial results.<sup>23</sup> We have not used it on patients because of the danger of opening the diaphragm with resulting complications involving the abdominal viscera.<sup>24</sup>

### OTHER CARDIAC OPERATIONS

Angina pectoris has been treated by cervical sympathectomy, by injection of alcohol into the ganglia of the thoracic sympathetic system and by complete thyroidectomy. Cervical sympathectomy has not given encouraging results. Total thyroidectomy has been recommended, but a final statement regarding it cannot be given at present.<sup>25</sup> These procedures treat the symptom of pain rather than the disease.

Several attempts have been carried out to relieve mitral stenosis by incision of the stenosed ring or by removal of a segment of the valve.<sup>26</sup> Stenoses of other valves (aortic and pulmonic) have been operated on; these operations on cardiac valves are still in the experimental stage.

COLONEL CLAUDE S. BECK

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## XXIV. THE MEDIASTINUM, INCLUDING THE ESOPHAGUS

### MEDIASTINAL EMPHYSEMA

*Tension emphysema* (presence of air) of the mediastinum is particularly important because it threatens life and demands emergency treatment. As the pressure rises the great veins are collapsed and the return of blood to the right heart is so compromised that death from circulatory failure may ensue in a few minutes. The superficial veins become engorged, the pulse becomes rapid and soft and the blood pressure falls steadily. Sauerbruch believes that severe emphysema originating in the chest wall may invade the mediastinum and produce the same effects.

**Treatment**—Most cases of traumatic emphysema require no treatment. The opening through which the air is escaping closes spontaneously and the air in the tissues is gradually absorbed. In the mouth or pharynx either suture or packing of the wound is a feasible and logical procedure. If the injury has been to the lung a roentgenogram should be taken to determine the nature of the injury and the presence or absence of pneumothorax and of air in the mediastinum. If ribs have been broken or if the chest wall has been penetrated and pneumothorax exists there is reason to believe that the air is escaping through the parietal pleura. In such cases a tight thoracic swathe may prevent further leakage and aspiration of the pleural cavity either at intervals or by continuous suction through a needle is indicated both to relieve a rising intrapleural pressure and to prevent further spread of the emphysema. Because the collapse of the lung favors the closure and healing of the wound aspiration should be done guardedly and only on the indications of severe emphysema or increasing dyspnea. Expectant treatment is often the best.

If there is reason to believe that there is involvement of the mediastinum the pulse rate and blood pressure must be carefully watched. A rising and weakening pulse and a falling blood pressure are indications for immediate surgical intervention. This is sim-

ple and safe aiming merely at relieving the pressure by allowing the air to escape through incisions made close to the site of egress from the mediastinum. The supraclavicular fossae posterior to the sternomastoids and the suprasternal notch are the locations of choice. The incisions should be carried through the platysma and the tissues spread by blunt dissection to the level of the great vessels. Air will escape rapidly at first and that which is at a distance from the incisions can be massaged toward them. Constant or intermittent suction applied by means of a vacuum cup attached to a suction apparatus is often necessary. The wounds will permit the exit of air for from twelve to twenty-four hours. The tissue spaces then become blocked by exudate and if the symptoms recur new incisions must be made.

JEROME R. HEAD

### MEDIASTINITIS

**Definition**—Mediastinitis is an inflammation occurring within the middle space of the chest limited by the spine behind, the sternum in front and the pleura on either side.

**Anatomy**—The mediastinum is a potential space of loose areolar tissue and while it is divided into anterior, middle, posterior and inferior divisions these are arbitrary and are not separated by well defined fascial planes or other structures. Hence there are no strict anatomical limitations of infection in the mediastinum. However fascial planes may direct infection from the neck to the anterior or the posterior mediastinum. The pretracheal space and the retrovisceral space are the major pathways for infection from the neck to the thorax.

**Etiology**—There are three main routes by which infection reaches the mediastinum: (1) the lymphatics and (2) the fascial planes from the neck or (3) by direct extension from structures within the mediastinum. There is an abundant supply of lymphatics with drainage from the lungs

neck chest diaphragm and abdomen and suppurative lymphadenitis might be expected to be the most common cause of mediastinitis whereas it is the least common. The fascial planes of the neck extend into the mediastinum the prevertebral pretracheal and middle cervical fasciae being continuous with the fascial layers in the mediastinum. Pus from a retropharyngeal abscess or cervical adenitis if allowed to progress may readily extend into the mediastinum. Operations in the neck as for esophageal diverticulum have resulted in mediastinitis. More benign conditions such as acute pharyngitis or laryngitis may give rise to mediastinitis usually by way of the lymphatics. The esophagus trachea and bronchi all potentially infected structures pass through the mediastinum and infection from these by direct extension is relatively common. Perforation of these structures by instruments foreign bodies ulceration or tumors is not uncommon. During World War I autopsies on patients with pneumonia and empyema showed 12 per cent with mediastinitis. Osteomyelitis of the surrounding structures—the sternum ribs or vertebrae—also may result in mediastinitis.

**Pathology**—The most common infecting organism is the streptococcus although a great variety of organisms have been described. For clinical purposes two forms of infection may be described: (1) local supuration or mediastinal abscess and (2) the diffuse form termed phlegmonous mediastinitis. The former more commonly follows the direct extension or perforation of pus into the mediastinum while the phlegmonous variety is more commonly of lymphatic origin. Owing to the loose areolar tissue of the mediastinum there is usually no encapsulation as in abscesses elsewhere and an abscess beginning in the posterior mediastinum may extend through the middle to the anterior mediastinum or vice versa. Phlegmonous (non suppurative) mediastinitis frequently is accompanied by bilateral suppurative pleuritis especially in the posterior mediastinum. It is likely that acute mediastinal lymphadenitis is more frequent than is commonly recognized.

**Diagnosis**—It has been pointed out that the pathologic picture of mediastinitis is varied consequently the clinical manifesta-

tions are seldom alike. The signs and symptoms usually described—chills fever prostration severe toxemia and interference with the circulation—are the exception rather than the rule. The fulminating type of the disease may present this picture but more often the disease is slowly progressive and not infrequently with remission. The signs and symptoms must be interpreted in the light of possible involvement of any of the structures passing through the mediastinum such as increased venous pressure respiratory embarrassment dysphagia obstruction of the thoracic duct or involvement of the sympathetic vagus or phrenic nerves. The diagnosis of an early case of mediastinitis is difficult and may be arrived at only by exclusion of primary pulmonary or cardiac disease. The patient may present symptoms suggesting pneumonia but roentgenograms will fail to reveal evidence of such involvement and are usually likewise negative for mediastinal involvement. However later they may reveal a widening of the mediastinum or a globular shadow. Latent films particularly of the superior mediastinum may be helpful and a swallow of barium to outline the esophagus is extremely useful. Occasionally a fluid level may be demonstrated. It should be emphasized that posterior mediastinitis is frequently accompanied by pleural effusion which may be bilateral. The possibility of a foreign body in the esophagus or trachea should also be kept in mind.

**Treatment**—The treatment of mediastinitis should be directed at the cause whenever this is recognized such as a foreign body in the esophagus or a deep cervical abscess. These two factors alone account for more than half the cases of mediastinitis. When there is localized pus in the mediastinum drainage is clearly indicated. However there is another group of cases in which the clinical course signs and symptoms indicate pus in the mediastinum which cannot be demonstrated but in which an exploratory operation is indicated. While there are undoubtedly instances of mediastinitis with spontaneous recovery there are many more in which death ensues because of failure to drain pus which cannot be demonstrated without operation.

The superior mediastinum down to the



level of the third thoracic vertebra may be approached through the neck. Therefore, in cases of actual or threatening mediastinitis due to esophageal perforation or infectious bilateral exposure of the cervical portion of the esophagus for drainage and packing is indicated. The posterior mediastinum should be approached by resection of the posterior portion of three or four ribs and careful separation of the pleura from the bodies of the vertebrae. Every effort should be made to keep the pleura intact but even if the pleura is opened it is less dangerous than undrained mediastinitis. When pus is in the anterior mediastinum a substernal or parasternal approach may be used. The operative mortality is not as high as is frequently assumed. From one half to two thirds of the patients operated on survive whereas the reverse is true when an operation is not performed.

COLONEL ASHLEY W. OLCHTERSON

### TUMORS AND CYSTS OF THE MEDIASTINUM DERMOID CYSTS

In the literature the term dermoid cyst has come to include the epidermoid and dermoid cysts as well as the histologically more complicated teratomas of the mediastinum although from the standpoint of their pathology, symptomatology and treatment the e types of tumors may differ widely.

**Incidence**—Although uncommon intra thoracic dermoid cysts are not nearly so rare as was formerly supposed about 220 cases having been reported.

**Etiology and Pathology**—These tumors are congenital and are thought to arise from ectodermal rests or misplacements of bronchiogenic cells drawn into the thorax by the descent of the diaphragm and the heart. They are most frequently encountered in the superior and anterior mediastinum in front of the great vessels and often lying in contact with the pericardium. They may occasionally be associated with other congenital anomalies such as spina bifida or exstrophy of the bladder. They are of slow growth and usually remain quiescent for a number of years rarely giving rise to symptoms before adolescence. Trauma or intra thoracic disease may serve to call attention

to their presence or may actually cause a more rapid growth.

**Symptoms**—Rarely appearing before the age of puberty dyspnea pain and cough are the common symptoms. The dyspnea appears at first only on exertion but becomes progressively more troublesome and late in the course may be paroxysmal in nature. The pain may be dull or acute and is sometimes referred to the shoulder or neck or down the arm. Cough may begin as a symptom of respiratory infection and may fail to subside as the infection clears or it may appear spontaneously. Sputum is usually scanty and confined to mucus occasionally blood streaked unless the cyst ruptures into a bronchus in which case the cyst content



Fig. 500.—Dermoid cyst of the mediastinum

consisting of hair and grumous material containing desquamated epithelial cells may be expectorated. Symptoms of vascular and neural compression may also be present and pleural effusion occasionally is seen. Fever may occur but is of low grade unless complicating infection is present.

**Clinical Course**—The cases of intra thoracic dermoid cysts have been divided into three groups on the basis of their clinical course. Usually the onset is insidious followed by the gradual progression of symptoms. Less frequently a very stormy course may follow an insidious onset the severe symptoms being associated with infection. More rarely still a stormy onset may be followed by alternating exacerbation and remission of symptoms.

Unless treatment is instituted the condition usually ends fatally. Thus in Arous

seau's series excluding 10 cases in which the cyst was discovered at necropsy there were 34 deaths in 34 untreated cases. However patients may live for a number of years after the onset of symptoms. 7 patients in Morris' series died in less than one year, 10 died in from one to five years and 12 lived more than five years after the first symptoms referable to the condition.

**Physical Signs**—The physical signs vary considerably according to the size of the tumor and the presence or absence of complications such as infection, rupture of the cyst, etc. On the whole signs of mediastinal compression are not common with dermoid cysts but with larger cysts the mediastinal structures may be dislocated. Occasionally the cyst may rupture externally, giving rise to a sinus from which hair and other elements from the cyst may be discharged. Lagging or bulging of the thoracic wall may be evident on inspection and percussion may reveal an area of dullness which may be taken for encapsulated fluid. On auscultation breath sounds may be absent over the dull area while rales or modified breath sounds may be heard elsewhere owing to bronchial compression.

In the x-ray picture a circular or oval shadow with a well defined margin is seen, its lateral border extending out into the pulmonary field but the medial border is always connected with the mediastinum. Lateral x-ray pictures may be useful in demonstrating the location of the cyst in the anterior mediastinum. The wall of the cyst may cast a distinct shadow particularly if calcification is present. If the cyst has ruptured into a bronchus it may collapse or a fluid level may be demonstrable within the cyst. Pleural effusion may obscure the shadow of the cyst which will appear only after thoracentesis.

**Treatment**—In the case of a cyst which is discovered accidentally in the course of a routine examination of the chest and in the absence of any symptoms the advisability of surgical intervention may be open to question but when symptoms and particularly those of pressure are evident treatment should not be delayed. Complete extirpation is the treatment of choice as in 76 cases this was followed by cure in 89.3 per cent with a 10.7 per cent mortality. In simple drainage of the cyst the mortality was

26.5 per cent and the cures only 15 per cent while with partial resection the mortality was 16.6 per cent and the cures 41 per cent.

### CILATED EPITHELIAL CYSTS

Simple cysts lined with ciliated epithelium have been found in the mediastinum and their origin in the thymus or in aberrant rests from the pharyngeal endoderm in connection with the development of the esophagus or air passages has been suggested. Such cysts may attain considerable size and commonly arise near the tracheal bifurcation or close to the lower portion of the esophagus.

### CYSTIC LYMPHANGIOMA

A few reports of cystic lymphangioma are to be found in the literature. These have been found for the most part near the tracheal bifurcation or in connection with the pericardium. Operation was attempted in Michaelis' case because of severe pressure symptoms but removal of the cyst was found to be impossible and the patient died.

### ECHINOCOCCUS CYSTS

Echinococcus cysts of the mediastinum are distinctly rare. Hare reported 8 and Hoffman 4 cases. Rose's patient was successfully operated on and cured after excision of the lining membrane of the cyst and drainage.

### TUMORS OF THE CONNECTIVE TISSUE

These include the fibromas, lipomas, fibroleiomyomas, xanthomas, chondromas, chondromyxomas, ganglioneuromas and neurofibromas.

**Fibroma**—Pure fibromas are rarely found in the mediastinum in most of the reported cases these tumors contained other connective tissue elements. In size they vary considerably and may become as large as a child's head. They are frequently adherent to the mediastinal structures or to the pleura or diaphragm. Like fibromas elsewhere they vary in consistency and are well encapsulated.

The symptoms of fibroma are those common to other benign tumors and may be present in varying degrees over a considerable number of months or even years. Pain in the chest, cough and dyspnea have been outstanding while hoarseness, pain and

swelling of the arm and dysphagia also have been noted

*Physical signs* do not distinguish these from other mediastinal tumors. Localized dullness and signs of bronchial vascular or neural compression have been the common findings. The x ray picture shows a clearly defined and circumscribed shadow extending into the pulmonary fields and blending with that of the mediastinum or heart.

*Diagnosis*—Positive diagnosis has been possible only at operation or necropsy. The commoner benign tumors of the mediastinum such as dermoids, lipomas or ganglioneuromas have usually been suspected.

The prognosis is excellent if operation is possible. In a group of 32 cases reported in the literature 18 of the patients who were not operated on died while of the 14 subjected to operation 13 recovered after removal of the tumor and 1 died.

*Neurofibroma*—The posterior mediastinum is sometimes the seat of a neurofibroma arising from the sheath of a thoracic spinal nerve. The clinical picture is that of the ordinary fibroma but pain is an early and prominent symptom and tends to radiate along the course of the intercostal nerves. When the tumor arises in the intervertebral foramen it may extend into the spinal canal as well as into the thorax giving rise to a so-called hour glass tumor. Such a tumor gives evidence of compression of the spinal cord and requires laminectomy as well as the racotomy for adequate removal. In the case of a neurofibroma arising from an intercostal nerve some erosion of the rib immediately above and below the site of origin of the tumor may be evident in the x ray picture which otherwise simulates closely that of ordinary fibroma.

The treatment is surgical and the outlook good provided the operation is undertaken before the tumor has become too large or has undergone malignant change. Of 21 reported cases 4 were found at autopsy. Operation was performed in 17 cases with 5 deaths (29.4 per cent) and 12 recoveries (70.6 per cent).

*Ganglioneuroma*—Although in some of the cases of ganglioneuroma the tumors have been located outside the chest—in the abdomen or neck, about 70 have been found in the posterior mediastinum springing from the thoracic sympathetic ganglionic

chain. They vary considerably in size and may be 15 cm in diameter. They appear as firm lobulated tumors the cut surface of which is gray and glistening. Microscopically they are seen to be made up of reticular net work containing groups of multipolar ganglion cells.

The symptoms are those of an intrathoracic fibroma but when Horner's syndrome appears early or is the initial symptom the diagnosis of ganglioneuroma should always be seriously considered.

Since this type of tumor is insensitive to radiation it should be subjected to operation for it usually can be removed often this can be done extrapleurally.

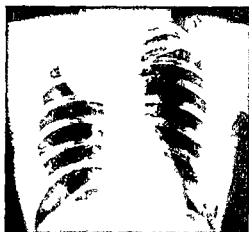


Fig. 10.—Ganglioneuroma arising from the paravertebral ganglionic chain. Operative removal was successful.

*Lipoma*—Lipoma of the mediastinum is rare; only 42 such tumors involving the thorax having been reported in the literature. Of these 40 arose in or at least involved the mediastinum. These tumors may conveniently be divided into three groups: one group comprising about three fifths of the total number in which the tumor lies completely within the thorax; another group in which intrathoracic and extrathoracic portions of the tumor are connected by a narrow isthmus traversing a perforation in the thoracic wall; and a third group in which a mediastinal tumor extends upward into the neck.

These tumors grow slowly and may attain great size; in one case (Leopold's) weighing 17½ pounds and are often slow in producing serious pressure symptoms.

While the presence in the x ray picture of

an intrathoracic shadow of clearly demarcated outline with its central portion denser than its periphery should make one suspicious of lipoma the diagnosis has seldom been made before operation or necropsy. When such a shadow is seen in the chest below an external tumor in the neck or presenting anteriorly and exhibiting the physical characteristics of lipomatous tissue the diagnosis is definitely suggested.

**Treatment**—Of the 13 patients in whom external tumors were present 12 were subjected to operation and 1 died untreated of mediastinal compression. Seven of the patients operated on were cured while 5 died. Of the 24 patients in whom the tumor was entirely intrathoracic 16 died untreated while of the 8 patients who were subjected to operation 5 recovered after removal of the tumor and 3 died.

**Chondroma Chondromyxoma Chondrosarcoma**—Primary cartilaginous tumors arising from the ribs and their cartilages from the sternum or from the vertebral column may project into the mediastinum. Of these tumors arising from the ribs and costal cartilages are by far the most common. They are not invasive unless malignant and indeed are usually well encapsulated and appear as circumscribed sharply demarcated often nodular tumors. They vary in size and may be as large as a child's head. Their consistency depends on whether the chief component is cartilage or the softer even semifluid myxomatous tissue. While many of these tumors appear grossly to be benign they are prone to undergo malignant change. Clinical and x-ray evidences of metastases in the lung are often present in the later stages of the disease.

**Symptoms**—Clinically these tumors are

more often seen in adults than in children. Pain is an early and often the only symptom its location character and severity being somewhat dependent on the site of the tumor. An external mass may be noted by the patient if the tumor involves the ribs and costal cartilages. Cough and dyspnea are of later onset and commonly increase in severity with the growth of the tumor. Symptoms of mediastinal compression suffusion of the face cyanosis vascular engorgement hoarseness or dysphagia or signs of pressure on the sympathetic trunk also may be present.

**Physical signs** may be meager at first later signs of mediastinal or bronchial compression and local bulging of the thorax appear. The roentgenogram shows a circumscribed shadow and its origin in the bony thorax may often be demonstrated.

**Treatment**—Surgical removal is the treatment of choice and the results in general are quite satisfactory. The operative mortality while decreasing is still fairly high and many of the patients have recurrences.

**Xanthoma**—In the literature there are references to 5 cases of mediastinal tumor diagnosed on pathologic examination as xanthomas. They are benign tumors and amenable to operative removal. The fact is significant that in one of the reported cases bloody pleural effusion was present.

## TUMORS OF THE MEDIASTINAL LYMPH NODES

The mediastinal lymph nodes may be the site of origin of a variety of tumors as indicated in the following classification modified from Ewing and based on the anatomical components of the nodes and the tumors arising from them.

Origin	Anatomical Type	Clinical Type
1 Lymphocyte	Lymphocytoma	Simple lymphoma
2 Reticulum cells	Large round cell hyperplasia or neoplasia	Lymphatic lymphoma
3 Endothelial cells	Endothelial hyperplasia	Lymphatic leukemia Pseudoleukemia Lymphosarcoma (small cell) Myeloid leukemia Malignant granuloma Hodgkin's disease Large cell lymphosarcoma Endothelial hyperplasia of fibrous or other connective tissue Endothelioma

**Lymphosarcoma.**—Lymphosarcoma has been the commonest type of mediastinal tumor in all large series in which careful pathologic studies have been made. In Ross' series of 60 cases, 44 were sarcomas, and of these 32 were lymphosarcomas.

Occurring most frequently between the ages of thirty and fifty and predominantly (in ratio of 2 to 1) in males, these tumors evidence no definite etiologic factors.

**Symptoms.**—The outstanding symptoms are pain, tumor or swelling and signs of mediastinal compression. The order in which the various symptoms appear may vary considerably, and any one may antedate the others. Cough, either dry or with meager expectoration, and dyspnea on exertion may be the initial symptoms. Hemoptysis is not uncommon, and low grade fever, usually under 100° F. in the absence of complications, is the rule.

The *physical signs* depend to a great degree on the size and location of the lymph nodes and when present are those of compression of various mediastinal organs. In addition, a swelling may be noted in the supraclavicular fossae or at one side of the sternum. X-ray pictures show widening of the mediastinal shadow and particularly of the supracardiac shadow, of varying outline and character.

Pleural effusion occurs in about 50 per cent of the cases, and in some of these cases characteristic cells may be found in centrifuged sediment of fluid obtained by thoracentesis.

If an enlarged node can be removed for histologic examination, the diagnosis is established; otherwise it must be made largely by exclusion. Benign lesions are less common and slower growing, and they show little change after radiation; whereas cases of both lymphosarcoma and Hodgkin's disease may be much benefited by x-ray treatment.

The disease is uniformly fatal and pursues a rapid course, the average duration of life after the onset of symptoms being under one year. Death may result from complications such as pneumonia or from exhaustion, asphyxia or cardiac failure.

**Treatment** is palliative at best, although temporary regression of the process, with considerable relief of symptoms, may often

be brought about by intensive use of deep x-ray or radium therapy.

**Hodgkin's Disease.**—Hodgkin's disease is of importance surgically chiefly from the standpoint of differential diagnosis, since it may cause many symptoms which are also found in cases of other mediastinal tumors.

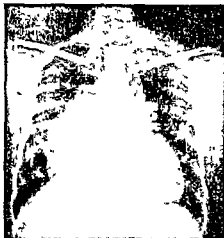


Fig 511—Lymphosarcoma of the mediastinal cervical and axillary nodes before treatment

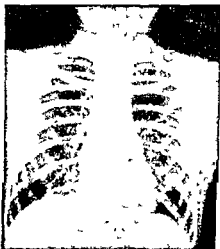


Fig 512—Same case shown in figure 511, three months after intensive x-ray treatment showing marked reduction in the size of the mediastinal nodes

Although certain prodromal symptoms, such as itching or eczematous eruptions of the skin, may occur, enlargement of lymph nodes is by far the commonest initial symptom, having been noted in 52 of 72 cases (72 per cent) of Gower's series, and in 71 (80 per cent) of Longcope's 86 cases. Beginning usually in the cervical nodes, the disease may spread to the mediastinum or more rarely may be primary in the mediastinal nodes.

The enlarged mediastinal nodes may remain discrete or may fuse into a more or less solid mass encircling the trachea bronchi or great vessels. In addition the lungs pleura pericardium cardiac muscle or liver may be invaded. The spleen is enlarged in about 10 per cent of the cases.

*Symptoms* of mediastinal compression predominate when the nodes in this region are involved. Pain in the chest may be retrosternal or referred to the shoulder or down the arm. Cough may be a prominent symptom and dyspnea and cyanosis are usually observed. Signs of vascular compression or of pressure on nerve trunks may be encountered.

*Diagnosis*—While the clinical and x-ray pictures of progressive enlargement of the mediastinal nodes are quite characteristic the differential diagnosis of Hodgkin's disease and lymphosarcoma rests largely on the histologic findings in an excised node even with this aid it may be extremely difficult at times. Fortunately however this differentiation is not entirely necessary from the therapeutic standpoint since both yield to a certain degree to x-ray or radium treatment. In both there is a great tendency to recurrence and while life may be prolonged for as long as several years cures are not effected.

*Endothelioma*—In rare cases the mediastinal nodes may be the seat of a primary endothelioma but more often these nodes are involved by secondary invasion of pleural endothelioma into the mediastinal structures. The differential diagnosis from other tumors of the mediastinal nodes can be made only after microscopic examination either of tissue or of the sediment of pleural effusion if it is present.

#### PRIMARY TUMORS OF THE THYMUS

The thymus may occasionally be the site of a benign tumor such as a cyst cystic lymphangioma lipoma or the very rare congenital myxoma but in nearly all cases the primary thymic tumor has been malignant. The neoplasm may originate either in the lymphoid or in the reticulum cells giving a histologic picture resembling on the one hand lymphosarcoma and on the other carcinoma. However because of the confusion which still exists as to the exact origin of the

different elements of the thymus recent writers have urged the inclusion of all primary malignant tumors of the thymus under the term thymoma.

About 100 such tumors are reported in the literature classified variously as lymphosarcoma carcinoma and sarcoma. Of these about 75 per cent have been diagnosed as lymphosarcoma.

The *symptoms* are those of progressive mediastinal compression and in addition pleural effusion fever loss of weight cachexia and anemia may be present. The tumor grows rapidly and causes death in a relatively short time. A number have been associated with myasthenia gravis (See section on Abnormalities of the Thymus).

*Diagnosis*—Except for the recognition of a mediastinal mass in the region of the thymus positive diagnosis can rarely be made ante mortem.

*Treatment*—The best results have followed intensive radiotherapy but its effects are palliative at best. In a few cases operation has been performed.

#### CARCINOMA OF THE MEDIASTINUM

Under this term is included a miscellaneous group of primary and secondary malignant tumors. A primary tumor arises from the reticulum cells of the thymus while a secondary tumor is the result of extension from a primary carcinoma of the lung trachea bronchus breast or esophagus or of metastases from a more distant focus.

Although distinctly less common a carcinoma arising in the same structure. It often reaches considerable size filling the anterior mediastinum and subsequently surrounds the trachea bronchi nerves or esophagus and extends to the pericardium pleura and lung. Metastases may occur also in the pleura lung liver spleen kidney and other organs.

*Symptoms*—In general the symptoms are those of pressure on the various mediastinal organs and some writers have emphasized the comparative frequency with which these tumors are associated with early vascular engorgement and swelling and edema of the abdomen and extremities due to involvement of the azygos vein. Serous or bloody pleural effusion is fairly common.

The diagnosis of mediastinal tumor is usually not difficult but the diagnosis of carcinoma depends on the availability of superficial nodes for biopsy.

Involvement of the mediastinum from carcinoma of the breast by extension may occur and in certain cases an attempt at removal of the lesion with the overlying ribs and sternum may be feasible although fairly prompt recurrence usually takes place.

While carcinoma of the esophagus often involves the mediastinal nodes, the occurrence of compression symptoms is rare.

WILLIAM DEWITT ANDRUS  
GEORGE J. HEUER

## THE ESOPHAGUS

Knowledge concerning diseases and functional disturbances of the esophagus has been developed slowly. This is due to the vagueness of symptoms early in the disease as well as to the inaccessibility of the esophagus. Usually some difficulty in swallowing first attracts the patient's attention but because in the beginning this does not seriously interfere with the intake of food he adjusts himself to the difficulty rather than consult his physician. As a result the underlying condition progresses until discomfort in the chest, pain, salivation, eructation, regurgitation of food or loss of weight alarm the patient sufficiently to make him seek medical advice.

On account of the deep position of the esophagus in the chest where it is inaccessible to palpation, ordinary means of physical examination fail. On clinical data alone the physician can usually only suspect an esophageal lesion. The symptom of dysphagia alone, however, should arouse suspicion and requires investigation with all known means.

Experience has shown that it is unwise to attempt blind instrumental manipulation. The cooperation of specialists is urgently indicated to establish the diagnosis positively.

The simplest examination is a roentgen examination with a contrast medium. By means of roentgenography one may study the position, size and shape of the esophagus as well as variations from the normal. Fluoroscopic examination permits a study of the function of the organ under normal

and abnormal conditions and cinefluorography allows permanent records to be made of such function. By these means a correct diagnosis can frequently be made.

In case the roentgen findings are inconclusive consultation with a peroral endoscopist is indicated for the purpose of performing esophagoscopy. The addition of the esophagoscope to the armamentarium not only has aided in the diagnosis of esophageal lesions but has permitted local treatment and the taking of biopsy specimens.

The esophagus is subject to affections similar to those found in other organs of the body. The age of the patient, the history of onset, the sequence of the development of symptoms and the site at which they are experienced may aid in determining what is the most likely lesion.

**Anatomy.**—The esophagus is a soft tube 9 or 10 inches in length composed of a thick outer muscular layer and a submucous coat and a mucous membrane. It reaches from the pharynx to the stomach. The upper end is guarded by a sphincter, the cricopharyngeus, which is largely derived from the inferior constrictor muscle. The lower end has a similar sphincter where it passes through the diaphragm. In its course it presents several constrictions which must be considered during instrumental examination. They may be responsible for retention of foreign bodies and are frequently the site of pathological processes. The esophagus permits of considerable distention. It is very delicate and may easily be ruptured by foreign bodies or careless manipulation of instruments. For purposes of description and on account of the differences in surgical accessibility the esophagus is usually divided into an upper or cervical, a middle or thoracic and a lower or abdominal portion.

**Physiology.**—During the act of swallowing an active voluntary contraction of the pharynx and associated muscles of the floor of the mouth forces food downward. At the same time a stimulus is set up which relaxes the upper and lower sphincters and after this deglutition is continued as an involuntary act. The further passage of fluids is largely due to gravity but for the passage of solid food active peristalsis of the esophagus plays an important role.

The most common conditions requiring medical or surgical attention are congenital malformations, trauma, impaction of foreign bodies, corrosion, ulcers, chronic granuloma, cicatricial stenosis, spastic conditions, diverticula, varices and tumors.

## CONGENITAL MALFORMATIONS

Congenital deformations are rare and of such a serious nature that most of the infants succumb during the first days of life.

Atresia of the esophagus with tracheoesophageal fistula comprises about three fourths of all esophageal malformations. Infants affected with such a condition usually die from starvation or from aspiration into the lungs. A few recent operative successes indicate progress in the treatment of this disorder. Congenital strictures may yield to the passage of bougies but a gastrostomy may be necessary to bridge over the early period. Congenital shortness of the esophagus with an intrathoracic stomach is an interesting condition which may be mistaken for stricture. It is usually not discovered until later in life either during a routine roentgenographic examination or because of symptoms. Appropriate treatment results in symptomatic relief.

### TRAUMA

Injury to the esophagus by external violence is usually associated with serious damage to other viscera. Trauma from within may be due to an increase in intraesophageal pressure causing spontaneous rupture to the passage or impaction of a foreign body or to instrumental manipulation. Since the passing of rigid instruments blindly is avoided the number of serious injuries is small at the present time. The passage of an esophagoscope is attended with a certain risk and great care is therefore necessary at all times. In case perforation of the esophagus is suspected early operation is indicated. The perforation usually occurs just above the cricopharyngeus muscle and the resulting spreading infection is therefore accessible from the neck. Notable successes have attended early operative intervention combined with other appropriate measures such as rigid mouth hygiene, the use of zinc peroxide and chemotherapy.

### IMPACTION OF FOREIGN BODIES

Most swallowed foreign bodies pass through the esophagus without difficulty. Large or irregularly shaped bodies however may become impacted at one of the normal anatomical narrowings (Fig 513) or at a pre-existing slight stricture while sharp objects such as safety pins may be caught in the mucous membrane at any point. Impaction of a foreign body at once leads to complications such as acute obstruction, in-

flammation, edema, spasm of the sphincter and secondarily periesophagitis, mediastinitis, empyema, etc. (Fig 514). One should therefore consider every patient with an impacted foreign body to be in grave danger and should take immediate steps to give re-



Fig 513—Coin impacted in the upper portion of the esophagus of a child.

lief. A roentgenogram is most valuable and may show the kind, size, shape and position of the object. A negative finding in a suspicious case is not conclusive and must be followed by esophagoscopy. One should be prepared not only to make a diagnosis but



Fig 514—Small object impacted in the lower esophagus of a child. The point of the pin had perforated the esophagus and pleura and produced empyema on the right side.

to remove the offending substance. With skill most foreign bodies can be removed through the esophagoscope. If the object is large and situated near or in the cardia it is at times advisable to remove it from below through the stomach. Esophagotomy is rarely indicated.



### CORROSION

Corrosion of the esophagus is caused by the ingestion of strong alkalis acids or hot fluids. Many patients die and in those who recover stricture formation develops. The immediate treatment consists in administering a neutralizing antidote and combating pain and shock as well as dehydration. A gastrostomy may be required. In order to counteract the tendency toward the formation of stricture the relatively early swallowing of a silk thread is advisable. This avoids complete stenosis of the esophagus and may later be used for the passage of bougies.

### ULCERS

There is no definite line of division between ulcers of the esophagus and esophagitis because in many cases of esophagitis acute or subacute ulcers are present. Ulceration may result from a variety of causes such as stagnation of food in cardiospasm and stricture the passage of instruments or foreign bodies retention of feeding tubes and regurgitated acid gastric content. Most of these lesions respond to local and dietary treatment but the so called chronic peptic ulcers may lead to hemorrhage or perforation.

### GRANULOMA

Tuberculosis syphilis actinomycosis and blastomycosis of the esophagus are occasionally encountered. They are usually secondary to involvement of other organs. They do not produce distinctive subjective symptoms and the diagnosis is usually made in connection with biopsy specimens obtained from one of the lesions. The treatment should be directed toward the general control of the disease aided by local applications or incision when feasible.

### CICATRICAL STENOSIS

Benign strictures of the esophagus may be congenital or acquired. Acquired strictures may follow trauma corrosion esophagitis simple ulceration or chronic granuloma. The symptoms consist of dysphagia and regurgitation of food. The diagnosis is based on the history of ingestion of a corrosive substance or of a preceding trauma. By means of roentgen examination it is usually possible to differentiate between a benign and a malignant stricture. In doubtful cases

an esophagoscopy examination is indicated. Treatment consists in gradual dilation by means of bougies. They may be passed from above or retrograde with the aid of a gastrostomy. On account of the danger of perforation bougies should not be passed blindly but only over a previously swallowed silk thread.

### SPASTIC CONDITIONS

Spasm may occur in any portion of the esophagus. It is the result of disturbance of the delicate balance between the parasympathetic portion of the autonomic nervous system and the sympathetic portion which control the physiology and normal deglutition. There are two recognized clinical entities associated with spastic conditions of the esophagus. One affects the upper portion and is known as the Plummer-Vinson syndrome. The other affects the lower portion and is best known under the name of cardiospasm. The etiology is not clear but evidence is accumulating to indicate that spastic conditions are due to a neuromuscular dysfunction. Recent investigations have unearthed many facts which support the theory that nutritional and vitamin deficiencies play an important role in the etiology. (See section on Cardiospasm.)

### DIVERTICULA

Diverticula are sac-like dilatations which project from the wall of the esophagus. They are classified into pulsion and traction types but a combination of the two may occur. Pulsion diverticula are supposed to be due to pressure from within which gradually produces a hernia or bulge of mucosa and submucosa at weakened portions of the musculature or at the points of penetration of blood vessels. Traction diverticula on the other hand as the name implies are supposed to be due to a pull from without usually by attached tuberculous mediastinal lymph nodes. Diverticula are most often encountered at the junction of the hypopharynx and esophagus about the middle of the esophagus and just above the diaphragm.

Pharyngoesophageal diverticula are the best known because of their frequency and clinical importance. They arise from the posterior pharyngeal wall just above the cricopharyngeus muscle and may reach a large

size (Fig 515) The symptoms depend largely on the size of the diverticulum and consist of difficulty in swallowing and regurgitation of food There is also frequent cough from aspiration as well as loss of weight from nutritional disturbance The diagnosis is readily made by roentgen examination if the condition is suspected Surgical treatment consists of extirpation of the sac The operation may be done in one or two stages Individual opinion the experience of the operator the size of the diverticulum and the general condition of the patient will determine the decision in favor of a one or two stage procedure

Supradiaphragmatic diverticula are also usually classed as pulsion diverticula They



Fig 515.—Large esophageal diverticulum filled with barium

are much less common than those arising at the junction of the pharynx and esophagus The symptoms simulate those produced by cardiospasm and may be relieved by instrumental dilation of the cardia Operative intervention is dangerous and is indicated infrequently Under consideration comes trans thoracic extirpation of the sac or abdominal esophagogastrostomy

Traction diverticula are not uncommon They are usually small and situated at the anterior wall of the esophagus in the neighborhood of the bifurcation of the trachea They usually produce no symptoms and are discovered accidentally during a routine roentgen examination of the esophagus They do not have a dependent sac and con-

sequently do not allow stagnation of food No surgical treatment is indicated for traction diverticula as such It is only when acute suppuration takes place that a drainage operation may become necessary

### VARICES

Esophageal varices are a common cause of serious bleeding from the esophagus They are usually encountered in cirrhosis of the liver or other conditions which produce portal hypertension The best method of establishing the diagnosis of esophageal varices is by roentgen visualization Attempts have been made to treat the condition either by a direct attack through the esophagoscope or by surgical intervention through the abdomen Surgical diathermy has been applied through the esophagoscope and lately esophageal varices have been successfully injected with a sclerosing solution The object of surgical intervention through the abdomen is to interrupt the venous channels between the portal system and the esophageal veins Ligation of the coronary vein and the vasa brevia of the spleen with or without splenectomy may be effective

### TUMORS

*Benign tumors of the esophagus* are rare and of little clinical interest Symptoms are usually present only when the growth is large or when multiple tumors are present The diagnosis can be definitely established only by means of esophagoscopy and biopsy Benign growths of the esophagus only rarely require external operation with esophagotomy Small tumors may be removed with biting forceps manipulated through the esophagoscope Pedunculated tumors may be snared off Occasionally the entire tumor may be destroyed by electrocautery or surgical diathermy

*Sarcoma of the esophagus* is a rare lesion and in many of the reported cases there is some doubt concerning the exact pathology The treatment of sarcoma is identical with that employed for carcinoma but to date no case of sarcoma has been treated successfully by radical operation Radiotherapy may be employed for palliation especially for lymphosarcoma

*Carcinoma of the esophagus* is a common disease According to different statistics

esophageal carcinoma constitutes from 4 to 10 per cent of all malignant growths. It is a rapidly fatal disease and is therefore one of the most important disorders of the esophagus. Carcinoma may occur at any level. The onset is insidious and for this reason medical aid is rarely sought until dysphagia has become manifest. Even then this symptom is often not given the necessary attention and the disease is allowed to progress until regurgitation of food, salivation, pain and loss of weight occur. All of these symptoms are late manifestations and at least partly explain why surgical treatment of cancer of the esophagus has not made more rapid progress.

**Diagnosis**—In experienced hands the diagnosis is usually easily made by means of roentgenograms which in a typical case show an irregular deformity with slight dilatation above it (Fig 516). Errors in diagnosis are easily made, however, and it is therefore important to perform a biopsy.

**Treatment**—Carcinoma of the esophagus usually comes under a surgeon's observation when the disease is far advanced locally and when as a result of malnutrition the patient has become emaciated and dehydrated; hence the treatment of this condition in most instances is limited to palliative measures. These consist of general medical care, the performance of gastrostomy, dilation of the malignant stricture, intubation, electrocoagulation and radiation therapy.

With the present state of our knowledge and with the type of patient referred to the surgeon, only a small group of carefully selected cases may be considered for radical operation. The pioneers in this field have established the feasibility of the operation and reliable autopsy reports on patients dying as the result of carcinoma of the esophagus have shown that at least 25 per cent have no demonstrable metastases. This knowledge should encourage surgeons to undertake the operation. Progress made during the last few years in anesthesia and chemotherapy has helped a great deal in the avoidance of serious complications. Improved preoperative and postoperative care have also been important factors. Every case requires careful study and adequate preparation with a view to utilizing all safeguards before the operation is undertaken. Because of various

technical and physiologic problems encountered in operations on different portions of the esophagus it is best to consider treatment of these different segments separately.

**1 Carcinoma of the Cervical Portion of the Esophagus**—The lesion may be removed from above. At times the larynx and pharynx must be sacrificed; a reconstruction operation may be considered later. Gastrostomy is usually advisable. The operation is a formidable one, and in view of the good results occasionally reported from external radiation in cervical esophageal carcinoma such treatment may be preferable.

**2 Carcinoma of the Thoracic Portion of the Esophagus**—Cancer of the middle por-



Fig 516—Typical carcinoma of the lower esophagus showing irregular outline of the obstructive lesion.

tion is technically the most difficult and dangerous to remove. During the last few years the operation has been successfully performed with increasing frequency by surgeons in all parts of the world. Most often the transpleural method described by Torek is employed. After preliminary gastrostomy the thorax is opened wide along the seventh intercostal space. The esophagus is divided below the tumor and the lower end is invaginated into the stomach. The upper portion of the esophagus with the tumor is then completely freed and brought out at the neck. After removal of the involved segment the upper esophageal stump is drawn through a tunnel beneath the skin to form an esophagostomy. By means of a rubber esophagus the esophagostomy and the gastrostomy are



Fig. 517.—a Patient after resection of the esophagus showing Jareway gastrostomy opening and subcutaneous tube at upper end of esophagus on chest wall b with rubber esophagus in place

then connected to permit swallowing (Fig. 517). A reconstruction operation may be considered later.

**3. Carcinoma of the Lower Portion of the Esophagus and the Cardia.**—Because of the possibility of restoring normal function operations for carcinoma of the lower portion of the esophagus are more favorable than those for cancer situated at a higher level. Depending on its extent the lesion may be approached through the abdomen, through the thorax, or by a combined abdomino-thoracic incision. In view of the uncertainty concerning the upward extension of the growth the transpleural route is usually preferable. The incision is made along an intercostal space or through the bed of the eighth or ninth left rib. The diaphragm is split and the upper end of the stomach, the cardia and lower portion of the esophagus is mobilized. After resection of the tumor-bearing area the stomach is closed and the fundus is drawn up into the thorax and fastened behind the esophageal stump. The latter is then implanted into the fundus usually with the aid of two rows of interrupted silk sutures. Direct continuity of the alimentary canal is thus re-established. It has been found that by adequate mobilization of the stomach the fundus can be brought fairly high within the thorax and

the establishment of a safe and satisfactory esophagogastrostomy permitted. Application of this procedure has therefore been extended to include some cases in which the Torek operation was formerly deemed necessary.

**Operative Results.**—Definite progress is being made in the surgical treatment of carcinoma of the esophagus. Numerous successful cases have been reported singly or in small groups in the American as well as in the European literature and they hold out the hope that this dreaded disease is gradually being conquered.

CARL EGGETT

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## CARDIOSPASM (ACHALASIA)

Idiopathic dilatation of the esophagus without anatomic stenosis more commonly designated as cardiospasm is second in frequency to carcinoma in producing symptoms of esophageal obstruction

It is a condition in which there is a constant spastic contraction of the cardiac portion of the esophagus without anatomic stenosis but with more or less dilatation of the esophagus above the point of obstruction The cardinal symptoms of the disease are epigastric pain dysphagia and regurgitation Frequently such pulmonary symptoms as cough expectoration fever and asthmatic seizures result from aspiration of portions of the content of the esophagus or from pressure of the esophagus filled with food

The etiology of the disease is not known but a disturbance in the nerve muscle mechanism of the esophagus and cardia is the most likely cause The disease may begin either gradually or suddenly and it may occur at any time of life It is questionable whether contraction at the cardia observed in infants a few days old represents true cardiospasm although authentic cases of cardiospasm have been seen in children two years of age There are slightly more males than females affected with the disease

Cardiospasm is not a neurosis and persons with a nervous temperament are no more susceptible to the disease than those of a phlegmatic type It seems that the disease is primary in the majority of instances although one occasionally observes associated lesions in the appendix stomach or gall bladder When such a lesion is observed in association with cardiospasm it should be considered merely as coexistent elimination

of intra abdominal disease rarely affords relief from the symptoms associated with cardiospasm

Between 60 and 70 per cent of sufferers from cardiospasm experience some degree of epigastric pain In many instances this is severe and may require hypodermic injections of morphine for relief The pain must be distinguished from that arising from gall stone or from angina pectoris

Dysphagia may vary in intensity but it is present at almost every meal As a rule the patient experiences more difficulty with liquids than with solid foods and cold water seems to cause more distress than other liquids

Regurgitation usually occurs immediately after swallowing in the early stages of the disease later however when the esophagus becomes more dilated the ejection of food may be delayed for longer periods of time Nocturnal regurgitation and aspiration of food and mucus may be particularly annoying and may result in loss of sleep or in the production of acute or chronic pulmonary suppurative disease

Cardiospasm should be suspected when the cardinal symptoms have been present for more than a year and when there is no history of the ingestion of a caustic which might have produced a cicatricial stricture Roentgenologic study will reveal a smooth obstruction at the cardia with more or less dilatation of the esophagus above this point The passage of a 41 French sound over a previously swallowed twisted silk thread is accomplished without detecting obstruction as would be the case if carcinoma or an inflammatory lesion were the cause of the stricture

Esophagoscopy is of value in differential diagnosis and should be carried out whenever there is any question as to the cause of obstruction Medical treatment rarely affords even temporary relief from symptoms and the results from surgical exploration of the cardia have not been encouraging Plastic operation on the cardia entails a grave risk and should not be undertaken Efforts have been made to remove the sympathetic nerve supply of the cardia and some authors have reported favorable results However lack of knowledge of the exact nerve supply of the esophagus makes the value of this

method doubtful. Mechanical dilation of the cardia with a 60 French sound will provide temporary relief for 10 per cent of those suffering from cardiospasm, and almost all of those having recurrences after this treatment and the ones who are not benefited by it can be cured by dilating the cardia with the Russel hydrostatic dilator. The risk of stretching the cardia with this expanding

dilator after the passage of a 60 French sound is negligible

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## XXV. THE ABDOMINAL WALL

### DESMOIDS OF THE ABDOMINAL WALL

*(Fibromas of the Musculofascial Layers of the Abdominal Wall)*

**Definition.**—The term "desmoid" is commonly used with reference to the tumors found in the abdominal wall, although Masson states that at the Mayo Clinic they include in the classification tumors from musculoponeurotic structures elsewhere as well. The commonest site is the rectus muscle. The situation is more often below than above the navel.

report of one of the writer's cases stated: "The specimen appears for the most part encapsulated." Pfeiffer speaks of encapsulation. From the practical surgical standpoint, it is undoubtedly easy to leave infiltrating portions of the tumor in the surrounding musculature, occasionally they are found to be adherent to the periosteum of an adjacent bone.

The growths are firm and cut with a grating sound. Not infrequently, according to Ewing, the structure resembles neurofibroma with intertwining bands of fibers and cells. He states that the structure varies from a

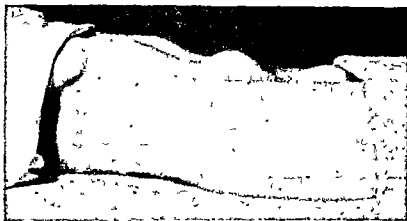


FIG 518.—Mrs M B (see text) Desmoid tumor of the right rectus muscle, first noted nine months after confinement

**Etiology.**—Pfeiffer, who collected the records of 100 cases, found that 87 per cent were in women, 94 per cent of whom had borne children. The greatest incidence in women is in the child-bearing age. These facts indicate that pregnancy is an important predisposing factor. Scars of previous laparotomies are also a recognized site (3 of 39 abdominal cases reported by Masson). He also reports a case in which a tumor developed in apparent relation to a direct injury of the biceps of the arm. Such facts support the theory that trauma is an important etiologic factor.

**Pathology.**—Masson says that these tumors are not encapsulated. The pathologic

hard acellular fibroma to a rather cellular fibrosarcoma. It should be emphasized, however, that desmoids are not malignant tumors and, while prone to local recurrence, do not metastasize. Sarcomas should not be included in the group.

**Symptomatology.**—The patient may experience discomfort from the presence of the lump, but otherwise there are no characteristic symptoms.

**Diagnosis.**—Desmoids are uncommon tumors. Masson reported 50 cases, of which 39 were in the abdominal wall, from the records of the Mayo Clinic in the course of nineteen years. They are to be distinguished from other tumors of the abdominal wall, inflam-

matory masses and intra-abdominal tumors. Two cases in the writer's practice will serve as illustrations

M B., a woman of about thirty, had noticed a lump three years before admission and nine months after confinement. The lump had enlarged and given occasional twinges of pain. Examination showed that there was a mass about the size of an orange just to the right of the midline below the navel. It was at first thought to be an intra-abdominal tumor, but careful examination showed that it was situated in the abdominal wall. At operation it was found to involve the inner two thirds of the right rectus muscle with its sheath extending from the umbilicus almost to the pubis. The peritoneum was sufficiently adherent to be opened in the dissection.

H Y. was a woman of thirty-nine. She had had a previous laparotomy. She complained of pain and for two weeks had noticed the presence of a lump. On examination a mass the size of a lemon was found to

may leave a large defect in the musculature of the abdominal wall that is difficult to close. This was the situation in the first of the writer's cases reported above. Closure was effected with the help of three fascial strands from the patient's thigh, which were sutured back and forth over the defect. The result as far as the patient has been followed (about one year) has been satisfactory.

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#### PILONIDAL SINUSES AND CYSTS

(*Sacrococcygeal Ectodermal Sinuses and Cysts*)

**Definition.**—A pilonidal sinus is a congenital stratified squamous epithelium-lined sinus, with or without cystic formation, occurring in the soft tissues overlying the site of the sacrococcygeal hiatus. It is manifested by a single or multiple openings on to the skin (in rare cases openings may be absent), varying in size and located in the midline, with or without tumefaction beneath or slightly cephalad to the sinus openings. Immature hair shafts may or may not protrude from the sinus openings. There may be secondary sinus openings in the midline or lateral to the midline resulting from infection and abscess formation in the sinus or its cystic counterpart (Fig 520).

These sinuses may be divided into (1) true pilonidal sinuses and (2) sacrococcygeal dimple and dimple sinus (Fig 520, b, d, a, c). These sinuses and cysts are of common occurrence from infancy to old age.

**Etiology.**—Everyone is in agreement that these sinuses and cysts are congenital in origin, however there is considerable disagreement as to their formation (Mallory, Oehlkecker, Tourniaux and Hermann Aschoff, Gage, Stone and Fox). There are three principal theories, each being championed by various authors: (1) cystic remnants from the caudal end of the medullary canal (Tourniaux and Hermann, Mallory and Gage); (2) faulty development of the median raphe in the sacrococcygeal region, producing dermal inclusions (Lannelongue, Aschoff, Fox and others), and



Fig 519.—Mrs M B. (see text). The desmoid tumor sectioned.

be situated deeply in the upper end of a low midline scar. It was rounded and slightly tender. A provisional diagnosis of endometrioma was made. At operation the tumor was found to arise from the rectus muscle and its posterior sheath.

**Prognosis.**—The prognosis is excellent, but local recurrences may develop. This happened in 3 of 26 cases of desmoids of the abdominal wall followed at the Mayo Clinic. Pfeiffer, whose paper appeared in 1904, reported 21 per cent recurrences in women and 68 per cent in men.

**Treatment.**—Treatment consists of excision. Masson states that radiotherapy alone has not been successful in curing these tumors but may be used as a supplement to surgery. This is particularly desirable when it has not been possible to remove the growth completely. Removal of the tumor



(3) inclusion of dermal developmental structures analogous to the preen gland of birds (Stone) The

Tourneaux and Herrmann have demonstrated epithelium lined cysts in the sacrococcygeal area in a large

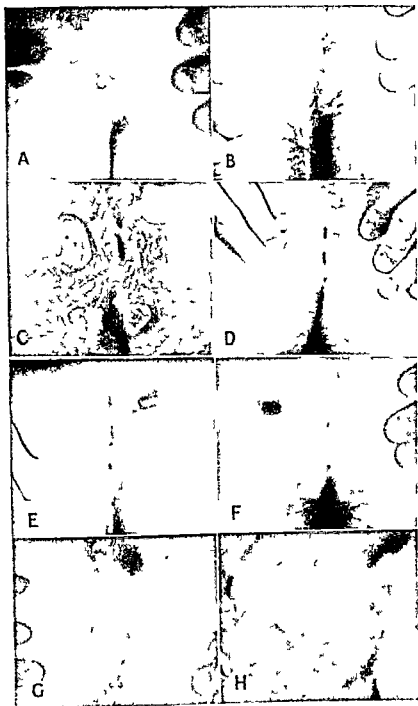


Fig 520.—Photographs demonstrating the various types of pilonidal sinuses and cysts and their complications. *a* simple sacrococcygeal dimple sinus. *b* and *d* uncomplicated and non suppurative type. *c* sacrococcygeal dimple sinus with accessory sinus opening near anus. *e* and *f* accessory sinus secondary to abscess formation. In *e* the sinus opening is to the right in *f* the sinus opening is to the left and at a greater distance from the pilonidal cyst than in *e*. *g* Accessory sinus in midline over sacrum with pilonidal sinus openings located below the sacrococcygeal junction. *h* pilonidal sinus (midline) with extensive scarring and accessory sinuses of left buttock due to repeated abscess formation. *a* neglected and unligated case.

author agrees with Mallory, Tourneaux and Herrmann that these sinuses and cysts have their origin from the caudal appendage of the medullary canal. Mallory,

number of fetuses which may or may not have connections with the skin surface. After many years of investigation the author is convinced that the theories

of Mallory, Tourneau and Herrmann can be substantiated and accepted. That these sinuses and cysts are intimately associated with the development of the medullary canal is also substantiated by the case reported by Walker and Bucy. These authors report a case in which the sinus was at the level of the fourth dorsal vertebra. The sinus tract extended from the skin surface to the cord proper.

The sacrococcygeal dimple and dimple sinus results from maldevelopment of the caudal ligament. The caudal ligament arises from the tip of the last coccygeal vertebra and is attached to the skin of the tail bud anlage. If the development of the caudal ligament does not proceed normally, the ligament remains short and pulls the skin into the form of a dimple over the coccygeal area. If this malformation becomes excessive, the dimple is converted into a dimple sinus (Fig. 520 a). The author has demonstrated this to be true in a number of cases by undercutting the tissue beneath the dimple. There followed immediate disappearance of the dimple which assumed the level of the surrounding skin.

The sacrococcygeal dimple and dimple sinus as well as the true pilonidal sinuses and cysts occur predominantly in the white race; their occurrence is said to be comparatively rare in the Negro. However, the author has seen a number of cases in the Negro and the occurrence in this race is probably more common than reported. The Negro is less prone to cutaneous infections than the Caucasian; therefore if he has a pilonidal sinus or cyst, it is less likely to produce symptoms. It is estimated that about 5 per cent of the white race have pilonidal sinuses or cysts. In the Army, an operation for pilonidal sinus and cyst is one of the most common if not the most common, elective surgical procedure.

**Pathology.**—There has been considerable disagreement as to the histology of these interesting but simple sinuses and cysts occurring in the midline of the sacrococcygeal region. The simplest form is the sacrococcygeal dimple. These dimples are very common and present little cellular pathologic evidence. There is however a peculiar phenomenon in that the epidermis of this lesion has no hair follicles. This is called the "sacral ball spot" of the embryo by Ohlwecker and the author has confirmed these findings. The sacrococcygeal dimple sinus points caudad and occasionally extends down beside the rectum as far as the external sphincter. A cystic dilatation of the caudal terminus may become several centimeters in diameter. The anorectal terminus of this sinus may be situated in the midline or laterally placed either to the right or to the left of the midline and in juxtaposition to the rectum. Hairs seldom protrude from the sacrococcygeal dimple sinus opening (Fig. 520 a). When infection and abscess formation occur within this sinus, a secondary sinus may develop which may simulate a fistula-in-ano (Fig. 520 c). These sacrococcygeal dimple sinuses are not common and secondary infection with abscess formation is of infrequent occurrence.

The true pilonidal sinus and cysts however present a different pathologic picture. The sinus tract may be situated superficially, just beneath the true skin, or deeply in juxtaposition with the periosteum over the sacrococcygeal area. The direction of the sinus tract

is always cephalad. There may be a single opening but usually there are multiple openings in the midline (Fig. 520 b d to h). Occasionally the openings may show cleft formation (Fig. 520 d). The sinus may be very short without associated cystic formation (Fig. 520 b). However, the sinus may be quite long and may extend upward in the midline or to either side. This lateral deviation is seldom of great distance from the midline. In many instances the cystic or bulbous end may extend up over the sacrum for some distance (Fig. 520 g). A somewhat similar condition exists in the two cases depicted in figure 520 e and f. In rare instances the sinus tract may extend into the sacral canal for a varying depth and even may be attached to the dura or continuous with it. Cases of this type have been reported by Mose, Ripley and Thompson and Gage. When the sinus tract is continuous with the dura (very rare instance) spinal fluid may or may not escape via the sinus tract. It is also conceivable that if the sinus tract is in juxtaposition with the dura, secondary infection of the tract may result in pyogenic meningitis.

The sinus tract and its cystic dilatation or bulbous tip is lined with stratified squamous epithelium. This epithelial lining extends through the entire sinus and its bulbous or cystic counterpart and is continuous with the normal skin at the dermal openings of the sinus. Numerous hair follicles develop from the epithelial lining and fine immature hairs protrude into the sinus lumen at times filling up the sinus and its cystic portion; hence the name *pilonidal* cyst. The epithelium in the majority of all cases reveals hyperkeratosis of the cornified layer with cracks and fissures extending through the epithelial lining. The perianal tissues show varying degrees of inflammation, both acute and chronic, characterized by infiltration of polymorphonuclear lymphocytes and plasma cells, with an occasional foreign body giant cell. The connective tissue surrounding the sinus tract reveals considerable productive fibrosis due probably to the ever present chronic infection. The collagen fibers are wavy and compact, simulating keloid formation. Granulation tissue is frequently seen budding into the lumen of the sinus through the cracks and fissures of the epithelial lining. Occasionally the sinus is almost completely devoid of its epithelial lining. In the latter instance the walls of the sinus and the lining are composed of granulation tissue.

In a histologic study of specimens in 80 cases, the author has noted no sebaceous or sweat glands arising from the stratified epithelial lining. However, both sweat glands and sebaceous glands have been seen in juxtaposition to the sinus tracts. By making serial sections of the specimens these glands can be traced to the overlying normal skin of the sinus tract. When the sinus tracts or cysts are superficial sweat glands and sebaceous glands from the normal skin covering penetrate to either side of the sinus tract.

Acute infection of the sinus tract resulting in abscess formation is of common occurrence. A pyogenic complication, fortunately rare, is carbuncle formation of the sinus and overlying integument. When the sinus and/or its cystic counterpart are superficially located and abscess formation occurs it points in the surface. Whereas when the sinus and its cystic portion are

deeply situated abscess formation usually points laterally, to the midline (Fig 520 e and f). When the abscess occurs within the sinus tract the epithelial structures are frequently destroyed. The same can be said of carbuncles. When the abscess occurs in a superficially placed sinus or cyst the abscess points and ruptures (or is incised surgically) resulting in a secondary sinus in the midline (Fig 520 g). When the sinus or its cystic counterpart is deeply situated and an abscess develops within the sinus it ruptures (or is incised) forming a secondary sinus lateral to the midline (Fig 520 e f h).

Occasionally a pilonidal sinus or cyst is found which has no openings on to the overlying skin surface. However there is as a rule a small timefaction in the midline near the sacrococcygeal junction. On careful inspection with the skin stretched tight one or more bluish spots of millimeter size can be seen with the epithelium at these sites only one cell thick. If the sinus or cyst is more deeply situated a small tumor mass is then the only indication of its presence. Fortunately this type of pilonidal sinus is rare.

**Symptomatology**—The symptoms of uncomplicated pilonidal sinus and cyst are practically nil with the result that a great majority of individuals go through life not cognizant of having this malformation. There are however several signs that denote the presence of a pilonidal sinus. 1 Single or multiple small openings occur in the median raphe of the skin overlying the sacrococcygeal area. 2 Hairs may or may not protrude from these openings. 3 An occasional discharge (desquamated epithelium and secretions from low grade non-symptomatic chronic infection) soils the patient's clothing. When symptoms are present they are indicative of acute infection with or without abscess formation. When an acute abscess is present the patient has severe pain in the sacrococcygeal area with general malaise. The abscess may point either in the midline (superficial sinus or cyst) or laterally to the midline (deeply situated sinus and cyst). There may be a slight elevation of the temperature depending upon the acuteness of the abscess and its intraluminal pressure. If a carbuncle develops in association with the sinus the local and systemic reactions are more pronounced. This complication is fortunately comparatively rare and the symptoms do not arise from the pilonidal sinus but from the superimposed acute infection. Therefore it can again be reiterated that symptoms from an uncomplicated pilonidal sinus are very rare. This is very important and immediately suggests

that a pilonidal sinus or cyst must be sought for in all examinations of patients. Some patients have a pilonidal sinus or cyst that has no openings into the skin surface and they may also have secondary abscess formation within the 'blind' sinus or cyst. Patients that have pain or abscess formation midline in the sacrococcygeal area without a sinus should be considered as having a pilonidal sinus or cyst without a skin connection until proved otherwise. A patient with a sacrococcygeal dimple or dimple sinus is unaware of its presence unless it is complicated by abscess formation.

**Diagnosis**—The diagnosis is not difficult if it is remembered that the presence of one or more sinuses in the sacrococcygeal region denotes the presence of a pilonidal sinus or sacrococcygeal dimple sinus with or without concomitant cystic dilatations. If an abscess is present in the same location either in the midline or lateral to the midline the buttocks should be separated and a search made for sinus openings. Not infrequently the patient gives a history of having had one or more abscesses in the sacral area. On examination a secondary sinus may be found its mouth being filled with a granuloma (Fig 520 e to g). All the photographs in figure 520 demonstrate the necessity of buttock separation to bring into prominence the pilonidal sinus area.

The differentiation between the true pilonidal sinus and the sacrococcygeal dimple sinus is not difficult. The direction of the true pilonidal sinus is always cephalad (Fig 520 e to g), whereas the direction of the sacrococcygeal dimple sinus is caudad (Fig 520 a and c). The only difficulty that may arise is in these cases in which a secondary abscess with sinus formation is near the anus (Fig 520 c). This type is frequently diagnosed as fistula in ano. If the nates are separated and the median raphe over the sacrococcygeal region is inspected no mistake will be made.

To determine the extent of the sinus tract a probe can be used or the sinus tract and its cystic counterpart can be injected with an opaque substance. Roentgenographic evidence can be obtained of the extent and direction of the sinus and cystic dilatations. The examiner should always determine the extent of the tract because the cephalad

end may extend into the sacral canal and may be either attached to the dura or continuous with it. There may be diagnostic difficulties with the blind type of pilonidal sinus. However, if the nates are separated widely and the skin over the sacrococcygeal area is carefully surveyed through a magnifying glass, pinpoint bluish areas can be seen in the midline. A probe can readily be pushed through this thin skin and into the sinus and a small tumor mass may be palpated beneath the skin in the same area. A probe can also be inserted into the secondary sinus (Fig 520 c e f) and may be pushed gently into the pilonidal sinus and/or its cystic dilatation.

From a study of all the photographs in figure 520 it is readily seen that the diagnosis of pilonidal sinus can be made without difficulty.

**Treatment**—The treatment of pilonidal sinus resolves itself into categories: (1) those cases that are complicated by an acute abscess and (2) those cases in which there is no infection and/or those in which the infection has subsided resulting in secondary sinus formation. (See Fig 520 g for the acute abscess b for the non infected pilonidal sinus and c e to g for those in which the infection has subsided leaving secondary sinus formations as a residual.)

There is no disagreement in the treatment of the cases with superimposed acute infections such as abscesses and carbuncles. The treatment is primarily conservative and never radical. The procedure of choice is incision and drainage. The incision should be adequate to promote free drainage. In making the incision extreme care should be taken that the knife does not penetrate beyond the limiting epithelial covering of the posterior wall of the sinus tract. The post-operative treatment consists of frequent hot sitz baths and daily dressings of the wound. Sulfadiazine in 1 Gm. doses four times a day will aid greatly in overcoming the infection. If the infecting organism belongs to the coccal group penicillin can be instilled once a day into the abscess cavity as well as applied to the first layer of the gauze dressing. If a carbuncle involves the pilonidal sinus it should be treated by hot moist compresses. Penicillin should be given intramuscularly 90 000 Foley units every three hours

both day and night until the infection is overcome. The sulfonamide drugs may also be used.

No radical surgical procedure for the ablation of the sinus should be undertaken within two to three months of the acute episode. In a large number of cases the acute infection within the sinus destroys the epithelial lining of the pilonidal sinus with the result that no further trouble from the sinus is experienced by the patient, a complete cure resulting. This desired result occurs only when the abscess points in the midline directly over the pilonidal cyst, the superficial type described in the section on pathology. When the abscess points to the right or left of the midline a secondary sinus invariably results. This complication is well demonstrated in the accompanying photographs (Fig 520 e and f). The surgical cure of pilonidal sinus consists of complete eradication of the sinus, its cystic counterparts and accessory sinuses. The various procedures advocated for the cure of pilonidal sinus have become almost legendary. The constant flow of new procedures in the literature is the result of failures following the use of surgical procedures previously advocated. There are three procedures that are widely advocated today: 1. The open procedure in which the sinus is simply opened and the wound allowed to granulate and heal over. The Buie operation is the best one of this type and consists mainly of incising into the sinus tract leaving the epithelial lining undisturbed. The edges of the wound are sutured to the epithelium of the sinus tract. 2. The use of sclerosing fluids injected into the sinus tract. This is the method advocated by Cutler and Zollinger and many others. The author does not advocate this method of treatment. 3. Complete surgical removal of the pilonidal cyst, its cystic counterparts and its accessory sinuses with a minimal sacrifice of tissue and primary closure of the wound. The author considers this the procedure of choice. All of the numerous surgical procedures advocated have as their objective ablation of the sinus tract, primary closure of the wound and prevention of recurrences. However, the majority of these technical procedures are so complicated that they defeat their purpose. Extensive tissue removal, various plastic flap

designs and extensive undermining of the wound edges have not relieved the desired results. The type of operative procedure to be used must incorporate sound surgical principles: i.e. the technic must be simple, the sinus tract and its various counterparts must be completely removed, absolute hemostasis must be obtained, a minimal amount of adjacent tissue should be removed, the wound edges must come together without tension, all dead spaces must be obliterated and primary wound healing must be obtained.

The preoperative preparation consists first of determining the type and the extent of the pilonidal sinus. One of the sulfa drugs, preferably sulfadiazine and vitamin C should be administered for at least four days before operation. Daily sitz baths are also advocated. The sinus tract can be injected with one of the colored dyes for the purpose of delineation. This is done as follows: The dye solution is injected daily for two or three days. Two days should elapse between the last injection and the day of operation. By means of this technic the tract is stained deeply by the fixation of the dye in its tissues—the so called drying out process. At operation the sinus and its various ramifications are thoroughly stained and there is absolutely no staining of the surrounding tissues.

**Operation.**—The best type of anesthesia in these cases is low spinal anesthesia. If inhalation anesthetics are given a clear airway must be maintained throughout the operation because the patient is in the prone position. After the patient is anesthetized he is placed in the prone position with a pillow beneath the lower abdomen and pelvis. Wide adhesive strips are attached to each buttock, pulled outward and downward and attached to the operating table. This gives a good exposure of the operative field by keeping the buttocks separated. The field of operation is widely prepared with mercuriolite and thoroughly draped. Every precaution should be used to prevent contamination of the wound during the operation. This is essential since the operative field is adjacent to the anus. An elliptical incision is made very close to the sinus openings to prevent sacrificing any of the overlying skin (Fig 501 J). The incision is extended up-

ward in the midline the length corresponding to the length of the sinus tract. The incision is continued downward until the sinus tract is exposed. The dissection is then continued laterally and downward until the caudal end of the sinus tract is freed (Fig 501 B). The freed end of the sinus is now grasped with Allis forceps and sharp dissection is continued upward, keeping close to the sinus tract until it is completely removed (Fig 501 C). If these simple rules are followed the pilonidal sinus is removed with a minimal sacrifice of tissue. If secondary sinuses are present (Fig 500 e and f) they are not disturbed until the primary sinus tract is removed. A probe can then be inserted through the secondary sinus from the skin surface into the wound. An incision is made over the probe and continued down until the sinus tract is exposed. The sinus tract is then dissected out with the probe in situ. This method does not sacrifice any tissue but the sinus tract. All bleeding points are ligated with fine cotton thread. Absolute hemostasis is necessary to prevent postoperative bleeding into the wound which inhibits wound healing and promotes infection. The wound is thoroughly irrigated with sterile normal saline solution and then dried with sterile gauze. Sutures of fine cotton (fine silk or fine catgut 0000 may be used, non absorbable sutures are preferable) are used to approximate the deep tissues (Fig 501 D). The skin edges are now approximated with the interrupted Davis stitch (Fig 501 E). Tension sutures to obliterate dead spaces and to approximate the wound edges are not advocated because they have a tendency to interfere with the circulation in the wound edges, thus preventing wound healing and increasing the tendency to infection. The operation described here so minimizes dead space formation that a simple pressure dressing agglutinates all wound surfaces. The wound is covered with several thicknesses of sterile gauze held in place by narrow strips of adhesive tape. A large fluffed out pad of sterile cotton waste is applied over the wound and fastened in place tightly with wide strips of adhesive tape that extend well down on the lateral aspects of the hips. This pressure dressing is most important because it obliterates all dead spaces, prevents wound exudation and capil-

## THE ABDOMINAL WALL

oozing and promotes rapid wound healing. The dressings should be sealed off from the anus with adhesive tape. If the sinus tract of the pilonidal sinus extends through the sacral hiatus and enters the sacral canal it will be necessary to unroof the sacral canal by removing two or

three vertebrae. This operation is more prone to develop because of its close proximity to the anus.

Postoperatively the patient should be kept in bed for ten to fifteen days depending upon the magnitude of the operation. A full diet can be given as soon as tolerated. Sulfadiazine is continued postoperatively for

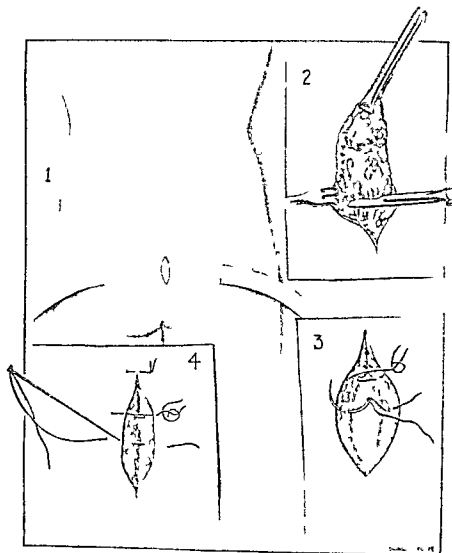


Fig 551.—A drawing depicting the surgical removal of a pilonidal sinus with minimal tissue sacrifice. 1 skin surrounding sinus opening. 2 sharp dissection of sinus tract with removal of a very limited amount of adipose tissue (the amount is exaggerated for definition). 3 closure of deep tissues with interrupted cotton sutures and 4 closure of skin incision with interrupted Davis stitch which prevents inversion of the skin edges.

of the sacral laminae. The operation is completed as previously described. The sacrococcygeal dimple sinus is treated in the same way as a pilonidal sinus. The only difference is that the latter sinus may extend to the anus being either anterior or posterior to the rectum. Postoperative infec-

tion is more prone to develop because of its close proximity to the anus. Postoperatively the patient should be kept in bed for ten to fifteen days depending upon the magnitude of the operation. A full diet can be given as soon as tolerated. Sulfadiazine is continued postoperatively for ten to fifteen days. Vitamin C in 50 to 100 mg doses three times a day is continued for at least a month after operation. Vitamin C converts precollagen fibers into true collagen fibers producing sound wound healing. The patient should not return to full physical activity under four weeks.

**Prognosis**—The incidence of recurrence ranges from less than 1 to 50 per cent. The majority of recurrences are due to faulty technique in obliterating the dead spaces. These dead spaces fill with serum and exudate giving rise to wound separation and chronic infection which result in the formation of a granulomatous sinus.

If the operation is performed as described with minimal sacrifice of tissue and with proper application of the pressure dressing the incidence of recurrence should not exceed 1 per cent which has been the experience of the author.

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## WOUNDS AND CONTUSIONS OF THE ABDOMINAL WALL

The local treatment of wounds and contusions of the abdominal wall does not differ from that of similar injuries elsewhere; their great importance resulting from the probabilities of associated visceral injury.

Gunshot and stab wounds may be divided for purposes of consideration into those that penetrate and those that do not penetrate into the abdominal cavity. The difficulty lies in deciding into which group a given case falls as tenderness and rigidity may be manifested with a wound of the abdominal wall only as well as when intra-abdominal hemorrhage and visceral perforation have occurred. Therefore unless it is clear from the findings that there has not been penetration as for instance gutter wounds or those whose entrance and exit are so close together that it could not have taken place, one should consider the injury as potentially penetrating and treat it as such. The importance of this matter arises from the fact that the result in wounds of the gastrointestinal tract treated expectantly is likely to be a fatality whereas exploratory laparotomy in cases in which no visceral injury is found is attended by a low mortality.

Every patient therefore with an abdominal wound in which penetration is seriously suspected both from the apparent course of the missile and the presence of pain, tenderness and muscle spasm should be subjected to an exploratory laparotomy as soon as possible after appropriate attention has been given to shock, provided adequate hospital facilities are at hand. In military surgery it was formerly considered safer not to operate on a patient with such a wound but the experience gained in the first World War has reversed this opinion. Of primary importance is the length of time which elapses between the receipt of the injury and the patient's arrival at a field hospital equipped for aseptic surgery. In civilian life except in isolated areas the victim of a wound will be hospitalized within a few hours. As the time before treatment lengthens the outlook for recovery after serious visceral injury grows more unfavorable. Lee states that patients with general peritonitis from a hollow viscus injury twenty-four or more hours old are generally hopeless subjects for radical treatment and the expectant plan should invariably be followed. Munro in *Keen's Surgery* quotes Siegel who collected reports of over 700 cases of penetrating wounds of the gastrointestinal tract and found that the mortality varied from 15 per cent in those patients operated on within the

first four hours to 87 per cent when operation was delayed beyond twelve hours after injury.

Contusions of the abdominal wall may present a more perplexing problem than wounds as regards the question of visceral injury inasmuch as the patient may be shocked with pain vomiting tenderness and rigidity without as well as with intra-abdominal injury. Bottomley compared a series of 90 patients with abdominal contusion without visceral injury with 20 in whom it was associated and came to the conclusion that there is no sign or combination of signs sufficiently constant to indicate whether or not visceral injury is a part of the picture. His conclusion in which one must concur is that in severe cases with signs suggestive of intra-abdominal injury exploratory laparotomy should be promptly performed.

The following case in which a tragedy was barely averted illustrates the difficulties of diagnosis as well as the importance of exploration in case of doubt. A forty-year-old workman was struck forcibly in the lower abdomen by a board and was knocked down. He went to a physician's office where he fainted. He was admitted to the hospital three hours after the accident complaining of constant sharp pain in the lower portion of the abdomen. On physical examination he was lying quietly in bed in moderate discomfort. There was tenderness in the lower portion of the abdomen most marked on the left side accompanied by local spasm and rigidity. The epigastrium was relatively soft. Rectal examination yielded no further information. There was no break in the skin. The temperature on entry was 99.1° F and the blood count to 90,000 with 86 per cent polymorphonuclears. The surgeon did not think immediate laparotomy indicated on the evidence presented but felt sufficient uneasiness to return for further examination a few hours later. By this time the temperature had risen to 101.8° F and the blood count to 90,000 with 86 per cent polymorphonuclears. Even then the abdominal signs did not seem altogether clearcut, but exploration was decided on. A perforation of the small bowel 6 cm in length was found with intestinal contents in the pelvis. The postoperative course was marked by persistent antipyrexia indicating a considerable degree of peritonitis but the patient finally recovered and left the hospital on the twentieth postoperative day. In retrospect it is easy to say that this patient should have been operated on at once on admission to hospital but it is not so easy to recognize the difficulty in recognizing the seriousness of the situation at the first examination.

In every case of abdominal contusion whether or not there are abdominal signs

the urine should be examined for blood as evidence of injury of the urinary tract. If the patient is able to void little or not at all the question of rupture of the bladder must be further investigated.

A blow in the epigastrium for which the patient is unprepared may be followed by immediate shock as evidenced by pallor sweating faintness and breathlessness particularly known as having his wind knocked out. Recovery is ordinarily prompt.

Among injuries of the abdominal wall special mention must be made of rupture of the rectus muscle and deep epigastric vessels. These cases are often called spontaneous hematomas of the abdominal wall. Although there are reports in the literature of rupture of the vessels without mention of muscular rupture it would seem that ordinarily the two conditions go together. The tearing of the muscle involving the epigastric vessels or their branches. The commonest site is below the navel where the muscle is said to be weaker. Wohlgenuth collected reports in 127 cases 107 of which resulted from considerable bodily effort such as jumping lifting and the like occurring mainly in young men. Cases also develop during pregnancy and labor and in debilitating diseases particularly typhoid. A rupture may take place however when a person is in apparently good health as a result of some trivial cause or with no apparent explanation. The patient often in older women complains of the sudden onset of pain with perhaps vomiting and faintness. Examination may reveal a mass due to the effusion of blood tenderness and spasm. The importance of these cases rests in the fact that they are often mistaken for intra-abdominal diseases such as acute appendicitis or ovarian cyst with twisted pedicle.

Morton reported such a case from St. Luke's Hospital on a man of twenty-eight who did not have a convincing history of trauma. The patient was thought to have acute appendicitis but at operation the appendix was found to be normal and a dark mass was seen bulging into the abdominal cavity under the right rectus muscle. The terminal incision was closed and a second incision was made to the rectus disclosing a large hematoma and a bleeding point in the deep epigastric vein.

A second case from St. Luke's Hospital was that of a man aged sixty-three who noted a swelling in the abdominal wall while undressing four days before ad-



There was a tender fluctuant mass below the navel to the left. It was thought to be an abscess but at operation it proved to be a large hematoma originating in the deep epigastric vessels.

Because of the difficulties of diagnosis many of these patients will have to be operated on but if the diagnosis is clear if the hematoma is small and not increasing in size and if the symptoms are mild rest may be all that is required. Otherwise evacuation of the clot ligation of the bleeding vessel and suture of muscle if necessary should be carried out.

An excellent article on hemorrhage into or beneath the rectus abdominis muscle by Cullen is recommended to those interested.

IT COL MORRIS K. SMITH

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## SURGICAL AFFECTIONS OF THE UMBILICUS

**Infections in the Newborn**—Since the advent of aseptic surgery sepsis originating in the umbilical stump has become relatively rare. It still occurs occasionally however and the possibility should be borne in mind in obscure illnesses in infants. The pyogenic cocci and colon bacilli have been the commonest invaders while tetanus from this source is not unknown. Invasion is by the umbilical arteries veins or lymphatics. Peritonitis may arise from direct extension.

The infant appears healthy for several

days after birth until it becomes evident by loss of weight irritability and very possibly a gastrointestinal upset that he is not well. Examination of the umbilical stump may explain the cause on the other hand general sepsis can arise at this point without being evident on inspection. The outlook is serious. It is apparent that prevention by careful aseptic treatment of the umbilical stump in the newborn is of utmost importance.

The treatment of the disease once it appears is that of sepsis in general drainage of any collection of pus that may form and supportive measures among which blood transfusion is important.

**Hemorrhage**—Hemorrhage from the umbilicus is not of common occurrence taking place most often at the time of the separation of the cord. It is more likely to occur in cases of infection. Besides local measures such as compression and ligation blood transfusion is indicated.

**Granuloma**—Granuloma of the umbilicus is the result of incomplete healing after separation of the cord. Ligation of the base excision and the application of silver nitrate suffice for the cure.

The appearance may suggest a polyp. In one such case in a seven week old infant the tumor 0.5 cm in diameter seemed at the first examination to be covered with epithelium. In order to be on the safe side treatment was given in the operating room so that a more extensive surgical procedure could be carried out if the condition proved to be a vestigial remnant with no abdominal connection. It was so clear that the mass consisted only of granulation tissue. It was treated in the usual way with prompt cure.

**Infections**—Infection of the umbilicus due to retained secretions are the commonest affections of the navel aside from hernia (see section on Hernia) encountered in adults. The deep recess with a narrow outlet favors the accumulation of sebaceous material in which hair and particles from the clothing may be mixed and the accumulation acting as a foreign body sets up an inflammation. Pain redness swelling induration tenderness and a purulent discharge ensue. The treatment consists in the removal of the foreign body which eliminates the source of irritation and allows drainage.

**Persistence of Embryological Structures**—Affections of the umbilicus due to

peristence of embryological structures although rare should not be forgotten by the surgeon. The omphalomesenteric or vitelline duct connecting the yolk sac with the digestive tract and the allantois from which the bladder is formed pass through the navel in early fetal life and occasionally remain wholly or in part as anomalous conditions.

A remnant of the omphalomesenteric duct may be present as a polyp sometimes called an adenoma and usually becomes apparent when the cord separates. The covering is of intestinal mucosa; it is red and secretes a mucoid fluid. The center consists of smooth muscle. If the vitelline duct has remained patent an opening will be found in the polyp. The opening may communicate with the bowel and cause the consequent leakage of feces. Cases of prolapse of the bowel through a patent vitelline duct are on record. In the case of a polyp the pedicle may be ligated and the polyp cut away. If there is a fistula the abdomen will have to be opened and the fistulous tract removed along with the navel.

A congenital vesical fistula which opens at the umbilicus is due to a patent urachus. After the patency of the urethra has been established the tract should be dissected out and removed together with the navel.

Urachal cysts present between the umbilicus and the symphysis. An infected urachal cyst or cavity may discharge at the navel and even open a communication with the bladder.

**Tumors of the Navel.**—Tumors of the navel of various types are recorded but are rare. It is one of the sites where endometrioma has been found. Carcinoma in this situation is usually secondary.

In the surgical records of recent years at St. Luke's Hospital there are reports of two cases of umbilical lesions other than hernia which came to operation illustrating the rarity of these conditions. In both instances the pathologic diagnosis was epidermoid cyst. The case report of one of these patients will serve as an illustration. The patient was a boy of six years who had had since birth an irreducible swelling at the navel. At operation Dr. Douglas removed a cyst containing cheesy material. The microscopic examination showed a thin lining of flattened squamous epithelium.

The writer wishes to acknowledge his indebtedness to Dr. T. S. Cullen's admirable and exhaustive book (*The Umbilicus and Its Diseases*, Philadelphia, W. B. Saunders Co. 1916) from which he has drawn almost exclusively in preparing this section.

LT. COL. MORRIS K. SMITH

## XXVI THE PERITONEUM

The peritoneal cavity is the largest cavity in the body. Like the pleura and the tendon sheaths the peritoneum is a serous membrane which is derived from the mesenchyme and is not epithelial in nature. It does not behave like epithelium either in function or in repair. The cells which form the peritoneal surface are flattened and polygonal and are separated from each other by a small amount of cement substance which can be stained with silver. The cells are similar everywhere except on the surface of the great omentum where the cells which do not rest upon fat form a synestium so that the organ when first removed from the peritoneal cavity has the appearance of a moist fly screen. Beneath the mesothelium in the parietal portions is a layer of loose fatty connective tissue called according to its location preperitoneal fat or retroperitoneal fat. Elsewhere for the most part the mesothelial cells lie upon a small amount of subserous tissue which covers the intra-abdominal organs. It is the subserous layer whether fatty or not which is the site of most of the activity of the peritoneum. In it lie the enormously rich capillary beds for the blood and lymph from which all nourishment must come and through which all absorption and exudation must take place. In this layer also are initiated most of the processes of repair.

### FUNCTION OF THE PERITONEUM

The peritoneum has a surface approximately equal to that of the skin. It is smooth and moist so that parts of its surface glide easily over one another. It has great capacity for absorption both of fluids and of small particles. As in other parts of the body absorption of fluids in general takes place most rapidly if they are isotonic with the body lymph. When fluids which are not of this character are introduced into the peritoneal cavity they are usually altered to isotonicity before much absorption takes place. The speed of absorption even of particulate matter is amazing. The process

is often recognizable in a few minutes after the substance is introduced. Another function is that of transudation or exudation. The peritoneum is not thought of as secreting as do epithelial cells. Probably this happens to some extent but the more important action is the transmission in a relatively unaltered state of substances which are brought by the blood or lymph. The peritoneum like other soft mesenchymal tissues also takes part in the processes of inflammation and repair.

### INTERDEPENDENCE OF PERITONEAL AND THORACIC CAVITIES

The peritoneal and thoracic cavities are usually treated as if they were remote from each other but the main body cavity is one which extends from the apex of the pleura to the hollow of the pelvis. It is divided only by the thin flexible diaphragm. The upper functional apertures can be thought of as the glottis and pharynx and the lower as the sphincters of the bladder and the anus. In the quiet act of breathing the contraction of the diaphragm increases the intra-abdominal pressure and the relaxed abdominal muscles are pushed forward. In the more complicated acts of coughing or straining the sphincters and the glottis must act in harmony or the contents of bladder or rectum may inadvertently be extruded. The same is true of the contents of an abdominal hernia of any kind. Conversely when the action of the diaphragm is embarrassed by distended abdominal viscera or by splinting because of abdominal inflammation breathing is limited and the lungs function abnormally. These are only a few instances of the functional relationship of the two cavities which may have clinical significance.

There are structural relationships which also are important. The abdominal muscles for instance are innervated by the lower intercostal nerves. Anteriorly the internal mammary vessels anastomosing with the deep epigastrics are closely associated with lymphatic channels which drain abdominal

and thoracic structures. In the retroperitoneal tissues the pathways connecting both cavities are large and numerous. Especially in the lymphatics of the diaphragm is found an intimate relationship for the inferior or subperitoneal network empties partly into supradiaphragmatic nodes and the superior or subpleural network empties partly into intra-abdominal nodes. The subpleural and subperitoneal vessels of the diaphragm also intercommunicate freely by means of perforating trunks. It is not surprising that clinical evidence of infections and tumors involving abdomen and thorax together is seen so often.

### PERITONEAL REACTIONS

Injury to the peritoneum may be of any character that affects other parts of the body. The commonest are mechanical and chemical the latter including the products of bacteria. The injury to the peritoneum may cause death of tissue or may merely set up the reaction known as the process of inflammation. If there is death of tissue or a break in the continuity of the peritoneum the process of repair will also be initiated.

(a) *Process of Inflammation*—This reaction can be well studied by injecting bacteria or chemicals into the peritoneal cavity of a laboratory animal in amounts that will be irritating but not lethal. Before the injection the peritoneal fluid is clear, acid and hardly greater in amount than is needed to lubricate the surfaces. It contains usually over 90 per cent large mononuclear cells, which are phagocytes. The remainder of the cells are eosinophils, small round cells with occasionally a polymorphonuclear basophil or small mononuclear to be seen. During the first half hour after injection inconstant changes occur. There may be transient appearances of eosinophils or small round cells. Before twenty minutes has passed polymorphonuclear leukocytes begin to appear and within an hour these cells come in a great flood which dominates the cellular elements of the fluid. A differential count at this time will show them to be well over 90 per cent with a tremendous quantitative increase as well. When three or four hours has passed mononuclear cells appear which stain deeply and which are almost surely young macrophages because shortly there-

after the adult macrophages are evident in large numbers. Meanwhile the peritoneal fluid has increased in amount and rapidly become more fibrinous. Clots of fibrin form which contain in their meshes wandering cells and foreign particles or bacteria if these were injected. The fluid is no longer uniform. By this time under favorable circumstances phagocytosis has occurred. The polymorphonuclears the first of the phagocytes to arrive can be seen actively engulfing bacteria or foreign bodies. They soon thereafter begin to disintegrate. The macrophages engulf bacteria and foreign particles and degenerating leukocytes as well. Both kinds of cells obviously perform a useful function and controversy as to which is the more important seems superfluous. As the days pass the degenerated cells and their phagocytosed contents disappear probably becoming dissolved or phagocytosed by fixed tissue cells. New macrophages keep appearing so that at the end of six or seven days the entire process of inflammation has seemingly subsided and the peritoneal fluid has returned to normal.

The periods of time given in the preceding paragraph are subject to wide variations and even the character of the reaction may change. If an overwhelming dose of micro-organisms is injected no wandering cells may appear and the animal may die of septicemia without being able to produce an inflammatory response. Also if a focus of infection is set up within the peritoneal cavity instead of a single injection of an irritant the timing and character of the response varies. But within limits the inflammatory response follows a constant pattern and is not specific for any irritant.

The appearance of wandering cells within the peritoneal fluid means that tissues remote from the peritoneum have been stimulated notably the bone marrow. The serous cells and the all important subserous tissues have also taken part in the reaction. The serous cells may become swollen or may disappear in places if the reaction is severe. The subserous tissues undergo the familiar changes of inflammation of soft parts, viz., edema, engorgement of capillaries and production of macrophages from the fixed tissues. In the omentum and elsewhere so-called potential vessels appear as small

vessels that normally do not conduct blood to any extent but do so actively during inflammation. In the fat columns around the vessels of the omentum and mesentery great production of phagocytes occurs. Meanwhile the lymphatics are active in transferring absorbed particles and substances in solution to the lymph nodes which drain the part of the peritoneum which is inflamed. Probably also there is a back and forth movement of lymph within the subserous vessels and a re-routing of lymph through channels which it ordinarily does not take. Thus effect if it does occur is of inestimable importance because it explains well the distribution of infection and of cancer through subperitoneal tissues which is familiar to all surgeons and which sometimes takes place very extensively.

(b) *Process of Repair*.—When peritoneum is divided or dies it undergoes repair in a manner similar to that of serous membranes elsewhere. The process of inflammation is set up in the course of which fibrinous fluid comes from the subserous layers and forms clots within the peritoneal cavity. Wherever the serous cells are injured these clots adhere and where an injured surface comes into contact with another injured surface or even with a previously uninjured one the two surfaces stick together by means of the clot. This is the first stage of adhesion formation. Later if this adhesion persists it may become organized by young connective tissue including blood vessels so that it becomes a living structure a fibrous adhesion and no longer a fibrinous one. Defects in the peritoneum are healed by the same sort of reparative tissue. The serous surface is renewed not by ingrowth of serous cells from the edges as defects in epithelium would be repaired but by metaplasia of the young connective tissue cells which happen to lie on the surface of the reparative tissue. These change from fibroblasts into flattened polygonal cells which are indistinguishable from the original serous cells so that a smooth surface is again formed.

The ultimate fate of adhesions is unpredictable. In general the more intense the inflammatory process the thicker the resulting adhesions. Peritoneal adhesions differ greatly in their capacity for forming adhesions. Some form

them to an extraordinary degree so that for the rest of their lives after an original peritoneal inflammation they are the victims of repeated attacks of symptoms caused by partial or complete intestinal obstruction. In other instances very extensive adhesions will disappear almost entirely in the course of a few months. The factors controlling the formation, disappearance and persistence of adhesions are not understood and attempts to alter their course by placing various substances in the peritoneal cavity have not been generally successful. Fortunately only occasionally do peritoneal adhesions cause symptoms. They are blamed for postoperative symptoms far more often than is justified. The best means of avoiding them include gentle surgical technique, minimal trauma to peritoneal surfaces from drying pads and retractors, adequate drainage of infections, avoidance of vertical incisions which cross many segments of intestine and perhaps making an effort to fasten the omentum into the upper abdomen where it is restricted as to the structures to which it can adhere.

## DISEASES OF THE PERITONEUM

**1 Peritonitis**.—Peritonitis means inflammation of the peritoneum not necessarily of bacterial origin. Every time the peritoneal cavity is entered at operation peritonitis follows. The usual cause however of clinically significant peritonitis in human beings is bacteria. Peritonitis is classified according to its extent as generalized diffuse or localized. The localized variety may be in the form of an abscess. Generalized peritonitis practically never occurs as a result of a focus within the peritoneal cavity such as appendicitis because even in fatal cases the process becomes arrested before the entire peritoneal surface is involved. It may be found in peritonitis caused by tubercle bacilli, hemolytic streptococci or pneumococci. Peritonitis is said to be localized when only a small portion of its surface is inflamed such as occurs sometimes in the neighborhood of an inflamed appendix. There is no line of distinction between diffuse and local peritonitis.

**Non Bacterial Peritonitis**.—Non bacterial peritonitis occurs in human beings when sterile irritating or traumatizing substances

gain entrance into the peritoneal cavity. Common causes are the instruments and gauze introduced at the time of operation body fluids such as bile or stomach contents which have escaped through a ruptured gastric ulcer. These substances may be sterile. Blood can be irritating to peritoneum after it becomes clotted or otherwise altered from its normal state. A ruptured ovarian follicle or cyst may cause sterile peritonitis. In the early stages of acute appendicitis of gangrene of the intestine or of acute mesenteric lymphadenitis there may be an excess of peritoneal fluid which is sterile accompanied by inflammatory changes in the peritoneum. The reaction caused by these irritants is a true peritonitis which is indistinguishable from peritonitis of bacterial origin except that the clinical signs of toxicity are usually less and the local signs of tenderness spasm or rigidity may be milder. However no surgeon is wise enough always to distinguish bacterial peritonitis from aseptic peritonitis with any degree of assurance.

Foreign bodies are nearly all irritating enough to set up some degree of inflammation if left in the peritoneal cavity. A smooth object such as a marble may move about within the cavity for a while but it is usually soon fixed in one site by adhesions which are the result of inflammation. More irritating substances such as a gauze sponge cause far more inflammatory reaction and abundant adhesions which mat together structures about the gauze and actually grow into its meshes. Dust particles in the peritoneal cavity can remain for long periods if they are inert or may be removed by phagocytes or even may form small fibrotic nodules. The symptoms caused by foreign bodies and the reaction around them vary from none to degrees of severity which require operation. If pathogenic bacteria are introduced with the foreign body an infection may follow which will not subside until the foreign body is removed.

**Peritonitis Caused by Intestinal Micro-organisms**—This is the usual variety of peritonitis and the commonest source is the appendix. The infection is usually caused by two or more varieties of organisms although in the early stages of an infection a single strain may be found.

(a) **CHARACTER OF MICRO-ORGANISMS**—The commonest organisms to be found are in the order of frequency some variety of the group of *E. coli* some strain of non-hemolytic or alpha hemolytic streptococci and *Cl. welchii*. None of these strains is apt to be of high virulence even when grown directly from fatal cases. It takes large doses of any of them to kill laboratory animals or human beings. Probably all of the strains of *Cl. welchii* most of the *E. coli* and some of the streptococci are toxin producers and herein lies their ability to produce fatal infections. Peritonitis may be thought of as a disease caused by great numbers of intestinal organisms of low virulence which produce toxins in a body cavity which has great powers of absorption. It is the toxemia and not the bacteremia which is fatal and the complications not the infection itself are the mechanism of death.

(b) **COURSE OF PERITONITIS SPREADING FROM AN INTRAPERITONEAL FOCUS**—One of the most important factors which control the course of an infection in the peritoneum is the speed with which micro-organisms disseminate from the focus. If the invasion of the wall of an appendix by bacteria for example is slow there may be time for an inflammatory reaction to occur always in advance of them. In this way fibrinous exudate may form on the serosal surface of the appendix and the micro-organisms however far they penetrate and cause death of tissue always remain walled off from the free peritoneal cavity by the adhesions which keep forming ahead of them. Such a process may well result in the formation of an abscess in which there may be much pus or sometimes only a little pus surrounded by a massive wall of inflamed hard tissues among which subperitoneal fat is apt to play a prominent role. But if instead of slowly penetrating a lesion such as a typhoid ulcer of the ileum suddenly ruptures and the filmy adhesions which covered it are torn apart there is then rapid flooding of the peritoneal cavity of greater or less extent by contaminated fluid and the area of contamination may be extended by gravity motions of the body or peristalsis. A relatively large focus of infection is thus suddenly set up from which absorption occurs over an extensive surface. This focus it is true may become limited by

the formation of adhesions but the chances of controlling the spread of infection and the toxemia are not so good as when the dissemination is slow. In both instances the barrier against continued diffusion of the infection is the adhesions.

After the initial infection whether rapid or slow the peritonitis develops according to the dictates of many factors. There are anatomical arrangements of the intra peritoneal organs and their mesenteries which control to some extent the direction in which infection spreads. A perforating duodenal ulcer for instance tends to force its fluid downward along the right side of the mesentery of the small intestine. Infections in the lower abdomen often point into the pelvis which is one of the customary sites for abscesses. From foci in the upper abdomen and sometimes for some reason also from the appendiceal region abscesses tend to form somewhere in relation to the liver either in it or above it (subphrenic) or below it (subhepatic). When the peritonitis is well controlled the formation of a single abscess near the focus may be all that occurs. In more diffuse processes multiple abscesses often form which may be distinct from each other or may be connected by complicated sinuses. The adhesions determine the limit of the pus in any case. Instead of actual abscess formation large masses of indurated tissues may develop which are impossible to distinguish clinically from abscesses and which may subside spontaneously. Small pockets of pus in these masses may be absorbed. Abscesses or inflamed masses of this kind may lead to fistula formation between various organs or between an organ and the outside of the body. It is important for the surgeon to know the routes of spread in the retroperitoneal tissues when dealing with these complicated chronic infections.

(c) **DIAGNOSIS OF PERITONITIS**—This involves a double duty, namely the determination of whether or not peritonitis is present and the identification of its source or focus. The diagnosis of peritonitis rests somewhat on the history which may be exceedingly varied but nearly always includes abdominal pain. There are no wholly reliable physical findings and the signs vary according to the length of time that the inflammation has been present, its extent, location and other

factors. It is easy to list the physical signs which ought to be present with peritonitis but it is often extremely difficult in examining any given patient to be certain whether those signs are there or not. In the early stages the patient may or may not look acutely ill, the temperature may be anywhere from very high to subnormal. The pulse rate is nearly always elevated. The respiratory rate is variable. The patient may be unwilling to lie with his legs straight out. Nearly always there is abdominal tenderness of greater or less extent and degree. The abdomen usually feels hard for some of its extent and this hardness may be due to spasm of the abdominal muscles or to a mass. It is well for the examiner to bear in mind that he cannot always tell the cause of the resistance to his palpating hand and not to interpret it too lightly. Tenderness or a mass may be revealed better by pelvic than by abdominal examination.

All of these physical findings may be the result of lesions other than peritonitis. Retroperitoneal hemorrhage, renal colic and pleurisy all may be accompanied by spasm or resistance on the part of the abdominal muscles. Even retroperitoneal tumors such as lymphosarcoma or Hodgkin's disease may cause signs that are indistinguishable from those of peritonitis. In a nervous or very obese patient it is often difficult for the examiner to be sure of the physical signs. One maneuver which may clarify a confused picture is for the examiner to press with some firmness on the anterior surface of the upper thigh where the patient will usually agree that tenderness is absent. The pressure is then applied at spots successively higher on the thigh until Poupart's ligament is reached. If when the examiner presses on the abdominal side of Poupart's ligament tenderness suddenly is manifest whereas below the ligament it was not present then peritoneal irritation is almost surely present and its cause must be determined. The usual sources of doubt lie in the interpretation of positive findings. The examiner wonders whether the tenderness he elicits is severe enough to be significant or whether the spasm is truly involuntary.

If it is decided that peritonitis is in all probability present the matter of determining its source or focus is a complicated one.

and is best described under the discussion of the various intra abdominal lesions

(d) TREATMENT OF PERITONITIS—The principles of treatment of peritonitis are (1) to prevent and treat the complications (2) to eliminate the focus of infection (3) to combat the micro organisms directly with drugs whenever possible and (4) to drain abscesses as soon as feasible

(1) The complications are often numerous and usually play a major role in prolonging the disease or causing a fatal outcome. Pneumonia usually occurs in severe cases. Toxemia may be the chief cause of the rapid pulse or even of cardiac failure. Jaundice, anuria, ileus and psychic changes. Ileus is often produced wholly or in part by organic obstruction which is especially apt to happen where intestinal coils come into contact with inflamed tissues and themselves become kinked or edematous. The organic factor should always be sought if ileus is present even in the presence of a silent abdomen for paralytic and mechanical ileus may be interdependent. The adjustment of fluid, chemical and cellular elements in the blood stream and thereby in the tissues is essential.

(2) Elimination or at least drainage of the focus of infection is as important in peritonitis as in any other infection. There are times when it may be wise because of the general condition of the patient to postpone this step, hoping that adhesions will wall the focus off, but the principle of earliest possible removal of the focus remains fundamental. It is in this matter that the technical skill of the surgeon may determine whether the removal of the focus in any given case is wise. An inflamed appendix removed in a blundering manner might perhaps better have been left to nature to combat.

(3) Little progress had been made in destroying the micro organisms directly until the advent of sulfanilamide. Sera were not successfully employed in spite of the vogue they had at one time in Germany. Other bactericidal products were not beneficial. The sulfonamide group however can be shown experimentally to be effective especially in the early stages. Once the micro organisms become entrenched in dead tissue and pus the effect of the drugs is lessened. They are never more than an adjunct in

the treatment but the clinical evidence is that they are often useful. Attempts have been made to increase the resistance of the peritoneum to intestinal bacteria by means of intraperitoneal injections of vaccines and other substances before abdominal operations. These would have no effect if injected after the infection had taken place but might produce a local immunity which could prevent an infection from starting. The evidence is that a certain small degree of non specific immunity can be produced but it is of no practical value.

(4) There are certain aspects of peritoneal abscesses that are distinctive and there is not usually need for hasty action in draining them. The surgeon often does well to wait till the abscess points very clearly before attempting incision. The reason for this is appreciated only by one who has tried to find in the peritoneal cavity pus whose whereabouts was not obvious. In the mass of inflamed tissues which can form within the abdomen adhesions may conceal identity of structures, planes of cleavage are indistinguishable, the operative field is obscured by uncontrollable oozing and guides and landmarks vanish. It is extremely easy to enter the lumen of the intestine or to cause bleeding from large vessels which in the friable inflamed tissues is hard to control. Great damage can be done and the pus perhaps not found. Peritoneal abscesses in the pelvis will often rupture spontaneously into the rectum or vagina if allowed to do so. It seems to be true that abscesses in other parts of the peritoneum also sometimes disappear perhaps as the result of rupture into a viscus or perhaps by absorption. It is hard to be sure how often this happens because the signs of peritoneal abscess can be mimicked by other conditions. Altogether the diagnosis and details of treatment of peritoneal abscess sometimes require a high degree of surgical ability and training.

(e) PERITONEAL DRAINAGE—When a peritoneal abscess is opened and also under certain other circumstances it is desirable to institute drainage. The matter of when and how to drain is a controversial one but there are fundamental principles for guidance. The purpose of a drain anywhere in the body is to keep the superficial layers of the wound open until the dead tissue and discharges in



the depths have separated and come away and the wound is ready to fill in with healthy tissue from the bottom. It is impossible to drain more than a small part of the peritoneal cavity at once. This is true not only because of the manifold crevices and pockets into which the cavity is divided but also because of the reaction of the peritoneum to a drain. The drain is always a foreign body and as such causes the peritoneum with which it is in contact to become inflamed and to discharge its fibrinous exudate. This exudate clots wherever the flow of fluid is not active thus forming adhesions about the drain which wall it off. Drains therefore cannot be effective for more than a few centimeters from their location. The importance of accurate placement of drains is obvious.

There are four principal reasons for draining the peritoneal cavity:

(1) The presence of gross amounts of dead tissue associated with micro-organisms. There is always dead tissue left behind after operations due to clamping and ligating of cut vessels injury by instruments etc., but these minute amounts in it be safely ignored. Gross amounts of dead tissue in the presence of infection or severe contamination should be drained.

(2) Insecure closure of a hollow viscus. The emphasis here is on the word 'insecure' and that is always a matter to be determined by the surgeon's judgment and experience. Sometimes closure of a hollow viscus must be done by approximation of inflamed tissues and the surgeon hopes that his sutures will remain intact but fears that they may not. Or the surgeon may believe that he has left too much tension on his line of suture or that the blood supply of the tissues he has approximated is not excellent or that undue pressure may arise within the viscus. Under such circumstances it is better to have a drain accurately placed to the point of danger than to risk escape of the contents of the viscus into the peritoneal cavity with no way prepared to the outside. An example of this is the stump of the cystic duct remaining after cholecystectomy which however securely ligated may open and allow bile to discharge.

(3) Uncontrolled bleeding. Raw surfaces may be left after operation which ooze in a

manner difficult to control. It is better to conduct the discharge outside the peritoneal cavity.

(4) The presence of exposed retroperitoneal tissue plus contamination. The reason for draining in this circumstance is that the tissues beneath the peritoneal cells are far less resistant to invasion by micro-organisms than are intact peritoneal surfaces.

The foregoing reasons are specific and there is usually little doubt in the operator's mind whether one of the conditions mentioned is present or is not. It is to be noted that contamination alone is not a reason for draining. The peritoneum can take care of a vast amount of contamination provided it is intact. No contamination of an area that is small enough to be controlled by a drain is to be greatly feared. Extensive contamination is dangerous but extensive areas can not be drained. When however contamination is associated with dead tissue or raw surfaces accurately placed drains are usually needed.

Much can be done to reduce contamination before the abdomen is closed. It is good practice to take time to aspirate accurately and carefully pockets in the peritoneum where fluid or foreign particles may collect. The pelvis the lumbar gutters and the recesses about the liver and kidneys often contain fluid. In this way the quantity of micro-organisms in these areas may be so reduced that the intact peritoneum can dispose of the remainder. Attempts to irrigate the peritoneum are usually unsuccessful but an irrigating tube with a suction tip attached to it may at times be useful. It is not yet clearly established whether placing drugs such as sulfonamides in the peritoneal cavity has any advantage over giving them by other routes.

The kind of drainage that is instituted must be fitted to the need of the case. If drainage is needed at all it is usually best to err on the side of providing excessive avenues of escape for the fluid. Where the fluid is expected to be small in amount and not too thick rubber tissues may suffice as they allow exudate to escape around them. They have the advantage of being soft and adaptable but the disadvantage of being difficult to adjust later except to shorten. If more than a little discharge is expected one or

more soft, black rubber tubes may be preferable, as they maintain a lumen if kept clean and can be slid back and forth to make sure that they are free. It is the sealing off of drains in the depths by fibrin which leads

to infected or badly contaminated cases, it may be wise to place the drains to the site chosen and then close only the peritoneum (with posterior sheath if the rectus is involved) for the remainder of the wound. A china silk

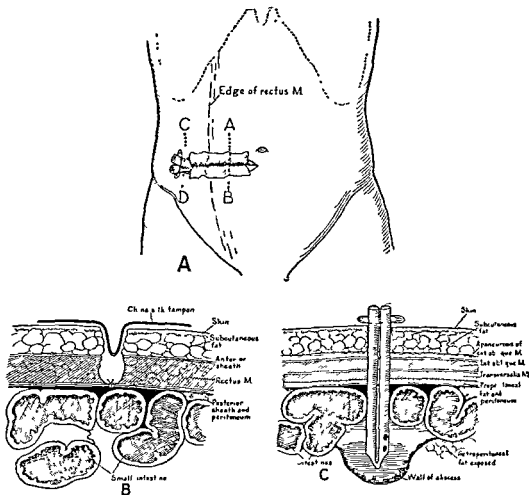


Fig 522—A man had a laterocolic appendiceal abscess with a cecum which lay in the right upper quadrant. A transverse incision was made over the mass, which lay in the flank about the level of the umbilicus. In order to gain working room the incision was carried medially across most of the right rectus. The large appendix was removed leaving the wall of the abscess behind and some retropertoneal tissue which was denuded of peritoneum. The medial portion of the wound, i.e., that part which involved the rectus, was closed to prevent evisceration by approximating the posterior sheath and the peritoneum, but in order to minimize the danger of infection of the abdominal wall, no other sutures were taken in the wound. A sheet of china silk was used to hold apart the subcutaneous tissues medially. The abscess was drained by means of a double rubber tube. The principles are to supply free drainage to the area where the dead tissue and contaminated exposed retropertoneal tissue are found, to prevent evisceration and to avoid so far as possible locking up micro-organisms in the abdominal wall. The area of peritoneum contaminated during the operation is too extensive to drain easily, and in any case there is no need to drain it, as it is intact. A, Showing location of the cross sections B, Cross section at A-B C, Cross section at C-D

to many disasters, and a drain that can be lifted off the bottom of its tract and then slid back into place has a great advantage. Often the problem arises of how to close part of an abdominal wound and at the same time drain through it. In dealing with in-

tampon may be loosely placed down to the closed sheath. In wounds of even great size, it may be best not to close the peritoneum at all but to place a silk tampon, filled with cigarette drains, firmly through the peritoneal layer, so as to wall off the viscera from the

rubber tube drains and at the same time prevent evisceration. It is a mistake to close tightly about a drain. The aim is rather to avoid closing wounds as far as possible in the presence of infection or expected infection. Drainage must also be free. A drain placed down to a leaking viscus or other focus even though it allows escape of some of the fluid may not prevent dissemination of the remainder throughout the peritoneal

commonest focus. It often appears as multiple, small gray pearly tubercles which shine through the mesothelial layer and feel like small shot placed in the subperitoneal tissue. This form of the disease is diffuse. It may also occur as localized involvement of one organ, where it may cause distortion due to scarring and contraction. In the large intestine for instance it may closely resemble carcinoma. It may go on to large areas of

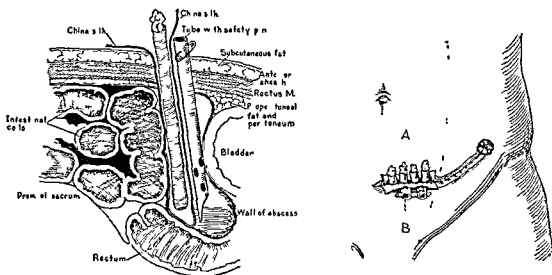


Fig 523—A transverse incision was made dividing the left rectus low down and extending upward and outward through the lateral abdominal muscles and the peritoneum under them. The sigmoid colon was resected because of severe recurring diverticulitis. The infection was limited to that segment of the bowel. Much of the sigmoid and the upper part of the rectum was removed. The rectal stump was turned in. A fistula between the bladder and the sigmoid was interrupted and the opening in the wall of the bladder was closed. An abscess was found in the cul-de-sac. The dissection was difficult; retroperitoneal tissue spaces were of necessity opened up over a large area and there was much contamination of the lower peritoneal cavity. The abscess wall deep in the pelvis was left in. The wound was treated as follows: The proximal end of the divided sigmoid was brought out through the lateral angle of the wound as a permanent terminal colostomy. The wound was closed in the peritoneal layer only in order to avoid infection of the abdominal wall between the colostomy and the lateral margin of the rectus muscle. In the medial portion of the wound a double soft rubber tube drain was placed down to the abscess in the pelvis. Cephalad to this was placed a tampon of china silk which contained numerous soft cigaret drains. The tampon was placed deep into the pelvis so as to fold back the intestines from eviscerating, and from coming in contact with the tube drain. Within forty-eight hours as the intestines became fixed to each other and to the peritoneum near the wound margin the cigaret drains were started out of the tampon. The tube drains meanwhile were moved slightly each day and irrigated. The china silk was removed at the end of a week, and the tubes were allowed to shorten themselves slowly.

cavity with fatal results. The safeguard is a means of exit to the surface that is sufficiently wide, accurately placed and direct.

**Special Types of Peritonitis**—(a) **TUBERCULOUS PERITONITIS**—This disease occurs more often in women than in men and in the young than in the old. It may occur as part of a miliary dissemination or may originate as it frequently does in some intraperitoneal organ. The fallopian tubes are its

commonest focus. It often appears as multiple, small gray pearly tubercles which shine through the mesothelial layer and feel like small shot placed in the subperitoneal tissue. This form of the disease is diffuse. It may also occur as localized involvement of one organ, where it may cause distortion due to scarring and contraction. In the large intestine for instance it may closely resemble carcinoma. It may go on to large areas of

the presence of fluid is demonstrable. The umbilicus is apt to be everted. It is a standard statement in medical literature that the abdomen has a doughy feel, but this is not literally true. The abdomen is not plastic but usually softly distended and not very tender. The treatment consists of general supportive measures, simple opening of the abdomen with aspiration of the fluid if the process is diffuse or often removal of a diseased focus if one is present. If the process is not associated with extensive tuberculosis elsewhere in the body, the prognosis is not bad.

(b) **GNOROCOCCAL PERITONITIS**—This comes from infection of the female genitalia. It is rarely fatal. It is important because it

mild degree of rigidity may characterize the illness. If a young girl has evidence of diffuse peritonitis without localizing signs over the appendix, a high leukocytosis and evidence of great prostration, the diagnosis of pneumococcal peritonitis must be strongly considered. Before the advent of penicillin and the sulfonamides, the disease was usually fatal, although it sometimes went on to abscess formation with or without recovery. Now the prognosis in cases recognized in time is greatly improved.

(d) **PERITONITIS CAUSED BY HEMOLYTIC STREPTOCOCCI**—In certain cases of widely disseminated even generalized peritonitis, hemolytic streptococci are found in pure culture. This infection may follow a strep-

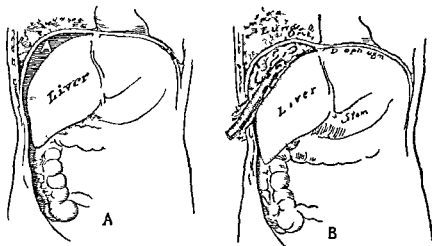


Fig. 324—A Subdiaphragmatic abscess extending from a paracolic abscess. B It is drained by both a gauze pad and a rubber drain.

resembles diffuse peritonitis of intestinal origin, especially that following appendicitis. If the diagnosis is not perfectly clear, it is better to explore the right lower quadrant and usually remove the appendix than to risk the dangers of postponed operation. The erythrocyte sedimentation rate is usually higher in gonococcal peritonitis than it is in appendicitis, but often a differential diagnosis is impossible. Sulfur drugs are usually effective in controlling the infection.

(c) **PNEUMOCOCCAL PERITONITIS**—This may occur secondarily to pneumococcal infections outside of the peritoneal cavity or may follow infection of the fallopian tubes. It occurs chiefly in girls under ten years of age. Diarrhea, distention and a surprisingly

toxic lesion elsewhere in the body, as for instance acute pharyngitis. The symptoms and signs are those of a severe infection with evidence of peritonitis. The treatment is chiefly the use of the sulfonamides or penicillin, proper handling of any discoverable focus, drainage of any abscess that may form and perhaps aspiration of the peritoneal fluid.

(e) **OTHER TYPES**—Evidence of peritoneal inflammation occurs in relation to acute rheumatic fever. The pathologic processes involved are not well known. Occasional cases are reported of peritoneal infection with microorganisms other than those previously

\* Hertzler in *Clinstophor Textbook of Surgery*, ed. 3, p. 1077.

described, many of these invaders probably coming from the intestinal tract. *Actinomyces* may cause peritonitis, and diffuse infections have been described in relation to lymphogranuloma inguinale and brucellosis. Almost any type of pathogen may be recovered from the peritoneal cavity as medical rarities.

Any type of peritonitis may become chronic. In these cases, the peritoneum becomes thickened, and adhesions are present. Chalk-like, hyaline deposits have been described, as in peritonitis arenosa. This condition is rare. When inflammation has lasted several days, so-called peritoneal irritation

myxoma or pseudomyxoma, sometimes called *hydrops spurus*. In the ovary, pseudomucinous cysts are the probable point of origin. In either case, the mucoid material escapes from the appendix or ovary and is discharged with bits of epithelial lining into the peritoneal cavity. These fragments are implanted into distant parts of the peritoneum or its organs and continue secreting so that lakes of thick jelly are formed. The jelly and the epithelium act as irritants, so that there is a reaction on the part of the peritoneum, with some inflammatory exudate and the formation of adhesions. The

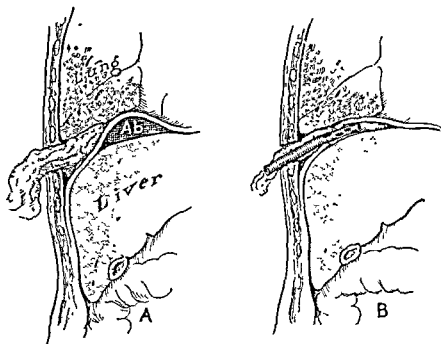


Fig 525.—Subdiaphragmatic abscess which is not accessible from the abdominal wall. A, a preparatory pack is placed in the thoracic cavity to secure a channel to the diaphragm, B, the abscess is drained secondarily.\*

cells may be found, which are groups of large mononuclear cells, probably phagocytic, which project from the peritoneal surface. An excess of clear or slightly cloudy sterile peritoneal fluid may be present in chronic peritonitis. It is apt to contain an unusually large number of macrophages. This may be found for instance in the free peritoneal cavity in the vicinity of an abscess.

2. *Pseudomyxoma Peritonei*.—This unusual condition, more casually known as "jelly-belly," arises in most if not all cases from a lesion in the appendix or ovary. In the appendix the source is probably a

ultimate result is masses of adhesions and gelatinous exudate which give rise to a variety of symptoms, such as distention, abdominal pains and changes in bowel habit. The treatment is removal of the focus, following which the implanted masses sometimes disappear. The prognosis for a long life is not necessarily altered by the condition. It is to be distinguished from colloid carcinoma with metastases, which can give a picture which is similar grossly, but the differential diagnosis can be made by the char-

\* Hertzler, in Christopher Textbook of Surgery, ed 3 p 1078

acter of the cells present as the lining cells in pseudomyxoma do not resemble malignant cells

3 Tumors and Cysts—Nearly all tumors of the peritoneum are metastatic. There is only one form of malignant tumor of peritoneal origin that is generally recognized and that is the so called mesothelioma. Other tumors arise in the retroperitoneal layers both benign and malignant similar to tumors of soft connective tissue elsewhere

in the body with which they are best classified. Cysts lined by cells resembling peritoneal cells are found frequently about the pelvic organs of the female. Subserous cysts occur having their origin probably in fetal remnants of the genitourinary system or in lymphatic channels. Cysts also occur as a result of infestation with animal parasites notably the echinococcus. Epithelial cysts such as dermoids are not truly of peritoneal origin.

HAROLD D. HARVEY

## XXVII. THE STOMACH AND DUODENUM

### CONGENITAL MALFORMATIONS OF THE STOMACH

*Congenital malformations occur less frequently in the stomach than in any other part of the gastrointestinal tract. Cases have been reported in which the stomach was found in the thorax as a result of a defect in the diaphragm either at the esophageal opening or in the right or left leaf. In these cases the stomach was quite normal except for its position. Other malformations which have been reported are atresia at the cardia or pylorus, congenital hour glass stomach and aberrant pancreatic tissue located at the pylorus. These conditions occur so infrequently however that for all practical purposes they may be disregarded. By far the most common congenital malformation of the stomach is congenital hypertrophic pyloric stenosis which will be considered in detail.*

#### CONGENITAL HYPERTROPHIC PYLORIC STENOSIS

Congenital hypertrophic pyloric stenosis was first described as a clinical entity in 1777 when George Armstrong reported a case in a three week old infant. In 1788 *Herakleus Berardus* reported the autopsy findings in a case. Williamson of London reported a typical case in a male infant in 1841. In 1842 *Simeon Davosky* was the first to note the projectile vomiting; he reported the first case in Germany, in that year. In 1879 Landerer first used the name congenital hypertrophic pyloric stenosis. In 1887 Hirschsprung called attention to the condition as being peculiar to infancy. In 1896 Finkelstein mentioned a palpable tumor for the first time. The greatest progress in the study and treatment of this condition has been made since the advent of the Fredet Rammstedt operation in 1912.

**Occurrence**—The incidence of pyloric stenosis is not accurately known but the condition occurs frequently enough so that the practitioner should have a clear understanding of the clinical picture and the

proper treatment. It occurs about seven times more often in male than in female infants and frequently in the first child of a family. It may occur in more than one member of a family. In one family of 12 children the first, fifth and ninth boys had pyloric stenosis. A girl whose father had been operated on in infancy for pyloric stenosis was operated on recently for the same condition.

**Anatomy**—The normal pyloric canal of an infant measures about 1.5 cm. in length. The pylorus projects into the duodenum as the cervix does into the vagina. In pyloric stenosis the entire pylorus is converted into a tumor because of hypertrophy of the circular muscle layer. All other elements of the pylorus are normal.

**Etiology**—The etiology of this condition is still unknown. Many theories have been advanced but none has been able to explain either the great muscular hypertrophy which is present at birth and which disappears after the Fredet Rammstedt operation or the occasional spontaneous cure without operation. It has been definitely proved that the tumor is present at birth from the examination of premature babies with well defined tumors but the symptoms do not usually become evident before the second week of life at which time the pylorospasm associated with the tumor begins. In all cases the hypertrophy precedes the spasm but it is the combination of the two that causes the pyloric obstruction. The severity of the symptoms is due to the variation in degree of the spasm rather than to the size of the tumor.

**Pathology**—In a well marked case the pylorus is characteristic. It appears as a firm white fusiform mass about 2.5 cm. long with a consistency about like that of cartilage. The tumor is freely movable, and the peritoneal coat is smooth and glistening. The lumen of the pylorus is probably never completely closed but it may be only large enough to admit a probe. On section the circular muscle coat is often seen to be five times its usual thickness but all other structures appear normal. As a result of the ob-

struction the stomach is both hypertrophied and dilated often to three or four times its normal size and in some cases its outline may be seen through the abdominal wall.

**Clinical Picture**—The clinical picture of pyloric stenosis is strikingly uniform. Vomiting which is always the first symptom begins in most cases between the second and the fifth week of life. Up to this time the infant has appeared quite normal. This vomiting which begins as a regurgitation soon becomes projectile and the quantity of vomitus is so great that it leaves no doubt that gastric retention exists. The vomitus never contains bile but may contain blood. The vomiting is so forceful that the vomitus may be projected several feet. It may occur directly after each feeding or if less frequent

has been palpated. The pyloric tumor in the right upper quadrant of the abdomen is the one sign that is pathognomonic of pyloric stenosis; it is found in no other condition and its presence therefore establishes the diagnosis. It may be felt in every case if the examination is properly made with the stomach empty and the child relaxed. Occasionally it is necessary to examine a child more than once to feel the tumor but with greater experience the physician rarely needs to make more than one abdominal examination. No patient should be operated on until the tumor has been felt.

The tumor is best described as feeling like a small olive but it varies considerably in size depending on whether or not the pylorus is contracted during the examina-



Fig. 526—*a* The stomach in a case of pyloric stenosis; *b* a normal stomach from an infant of the same age.

the amount vomited which represents the entire stomach content may be equal in volume to that of several feedings. Since the child is losing all his nourishment by vomiting he loses weight rapidly and soon becomes dehydrated and wasted. For the same reason he is constipated and passes only small amounts of urine.

Gastric peristaltic waves are visible in all cases. These vary considerably in intensity, being most striking in a late case. They are seen best when the stomach is full, starting at the left costal margin and passing to the right. More than one wave may be present at a time. While peristaltic waves are found in other conditions in infancy and therefore cannot be considered pathognomonic of pyloric stenosis, they are often helpful in establishing the diagnosis before the tumor

is felt. The tumor may lie anywhere in the right upper quadrant of the abdomen; if it lies under the rectus muscle it may easily be confused with the linea transversa. It is best felt when the stomach is empty and a clue to its location may be obtained by watching the point where the peristaltic wave ends. If pressure is made on the fundus of the stomach with the left hand while one palpates for the tumor with the right hand the tumor may be brought out from behind the rectus muscle or down from beneath the liver to a point where it is more easily felt.

**Diagnosis**—Since these cases run quite true to form an intelligently taken history and the recognition of peristaltic waves are helpful but the diagnosis depends entirely on feeling the tumor.

The diagnosis may be made roentgeno-



graphically, but in the writer's experience this method has been purposely avoided both because the diagnosis may be made without it and because the barium may increase the postoperative discomfort.

Pyloric stenosis must be differentiated from duodenal stenosis which is due either to congenital atresia or to a band. In pyloric stenosis the symptoms do not become evident before the second week, while in duo-

denal stenosis the symptoms are not severe and the infant is almost three months of age. With the present low postoperative mortality, of less than 1 per cent, it seems unnecessary to subject a baby to three months of vomiting and refeeding, as required by medical treatment. A baby, successfully operated on, is perfectly normal and able to tolerate a generous formula two weeks after operation. From an economic

Fig. 528

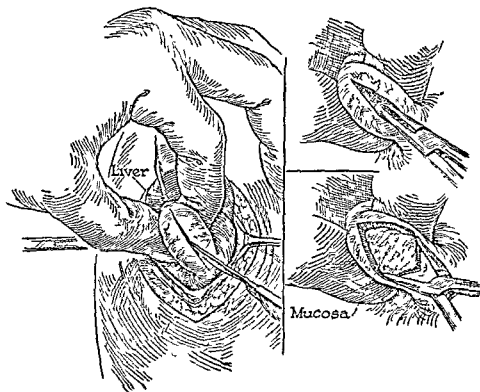


Fig. 527

Fig. 529

Fig. 527—First step of a Fredet-Rammstedt operation. Incision of the peritoneum and the superficial fibers of the circular muscle.

Fig. 528—Second step in the Fredet-Rammstedt operation. Starting the separation of the cut muscle edges with a mosquito clamp.

Fig. 529—Final step in the Fredet-Rammstedt operation. Separating the cut muscle edges until the mucosa completely fills the incision.

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**Treatment.**—After the tumor has been felt, the infant should be operated on as soon as he has been put in condition to withstand operation. The only exception to this rule

standpoint alone, surgical treatment is better than medical treatment, which must of necessity be prolonged.

**Preoperative Preparation.**—Preoperative preparation has probably been the most important factor in reducing the mortality to its present level (1 death in 400 cases). A few years ago these patients were operated on as for an emergency, with a high mortality as the result. Many babies died of shock because their condition was too poor to with-

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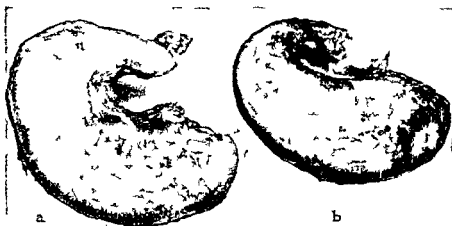


Fig 506—*a* The stomach in a case of pyloric stenosis *b* a normal stomach from an infant of the same age

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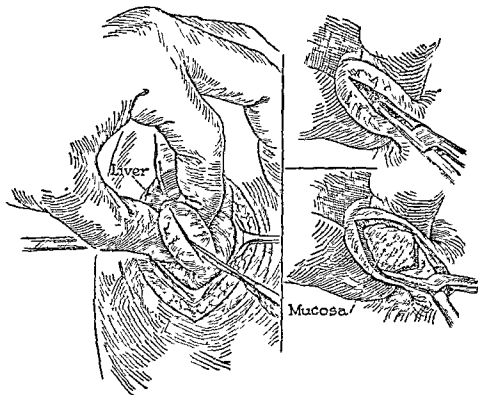


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stand any operation. At present the amount of vomiting and the kind of formula the baby has been receiving are disregarded and efforts are immediately made to overcome the dehydration. Hypodermoclysis of 100 cc of saline and glucose solution twice daily for two or three days is given until the fluid balance has been reestablished. If the infant's condition is desperate he may first be given either an infusion of 10 per cent glucose or a blood transfusion using 20 cc of whole blood for each kilogram of body weight. One or 1½ ounces of 5 per cent glucose solution which is often retained better than a formula of milk is given every two hours before operation.

After two or three days of this treatment there is a striking improvement in the baby's condition with the converting of a baby who might have been considered the poorest possible risk into one well able to withstand an operation. When dehydration is completely overcome the child is operated on the Fredet Rammstedt operation being used in all cases. Ether (open cone) is always used except in cases of infection of the respiratory tract when novocain is used. Ether given with an open cone is so well tolerated that a respiratory infection practically never occurs after operation.

**Operation**—A right rectus incision 5 cm long is made high enough to overlie completely the right lobe of the liver which acts as a buffer and prevents postoperative rupture of the incision in a poorly nourished infant. The right lobe of the liver is retracted upward and the pylorus is delivered into the wound. While the tumor is held between the thumb and the index finger of the left hand an incision is made over its entire length in the least vascular area cutting through the peritoneum and just starting the circular muscle. The cut muscle edges are then separated by inserting a straight mosquito clamp in the stomach end of the incision and spreading it until the mucosa completely fills the incision. Great care must be exercised in separating the muscle for fear of breaking into the duodenum since the change from the thick pyloric tumor to the thin walled duodenum is rather abrupt. The tumor is dropped back and watched for a moment or so to be sure that there is no bleeding from the cut surfaces. If there is much bleeding

the vessel may be ligated some distance from the cut muscle edge with a suture of fine black silk. The abdomen is then closed in layers using black silk (c) throughout.

**Postoperative Care**—After operation the infant should be kept in a room with a constant temperature, completely isolated from other patients. Great care must be exercised in the postoperative feeding as in many cases because of the use of a variety of formulas before operation the infant has a low food tolerance. For the first five days breast milk is given with a medicine dropper without picking up the baby. If the baby is to nurse he is allowed to do so once on the fifth day twice on the sixth day etc until he is completely breast fed. If he is to have a formula evaporated milk is well tolerated. This formula is given once on the fifth day, and if it is well tolerated it may be rapidly increased until the caloric requirements are met. Hypodermoclysis of glucose and saline solution is given daily on the first three days after operation. Skin sutures are removed on the fifth day.

It is unusual to have any but the smoothest convalescence. If a complete operation has been done the baby should not vomit after operation. If vomiting does occur it usually means that the stomach has not been emptied in the operating room. The passage of a stomach tube will produce an immediate response. In most cases there is a gain in weight before discharge on the twelfth day and in a month the condition is the same as it would have been had pyloric stenosis not occurred. The Fredet Rammstedt operation gives a permanent cure as the pylorus has been found to be normal in patients operated on later for other conditions. In contrast to this the pyloric tumor has been found years later to be exactly as it was in infancy if gastroenterostomy was done.

EDWARD J. DONOVAN

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## FOREIGN BODIES, GASTRITIS, GAS- TRIC HEMORRHAGE, WOUNDS OF THE STOMACH

### FOREIGN BODIES IN THE STOMACH

**Etiology and Varieties**—1 Swallowed  
(a) by inadvertence coins pins marbles  
buttons broken thermometers false teeth  
tooth brushes fragments of eating and culi-  
nary utensils pencil ends ticks nails dental  
and surgical material and tools food boluses  
fish bones (b) by intent nails tools wire  
twine glass etc by sword swallowers ex-  
hibitionists idiots and hysterical and de-  
mented persons Paretics may ingest objects  
large enough to result in strangulation  
Thieves sometimes swallow coins valuables  
and legal evidence Suicide is attempted by  
swallowing glass ticks etc Bezoars may be  
made up of plant fibers hairs or persimmon  
seeds or they may accumulate following the  
repeated ingestion of shellac furniture pol-  
ish or other solid residues in alcoholic sus-  
pension Bezoars may tampon the pylorus or  
the whole stomach 2 By penetration of the  
abdominal wall bullets shell fragments and  
missiles glass knife blades and other pen-  
etrating articles surgical drainage tubes  
(glass rubber and metal usually introduced  
through a fistula) Murphy buttons over-  
looked surgical instruments and dressings  
3 Of endogenous origin parasites (e g  
ascaris and taenia) gallstones or bone se-  
questra ulcerating into the stomach loos-  
ened fragments of tumors prolapsed gas-  
trostomy catheters and Levine and Abbott  
Miller suction tubes that have been bitten  
through or otherwise broken or spontane-  
ously knotted in situ

**Symptoms and Complications**—The gas-  
tric mucosa is insensitive to foreign bodies  
Such symptoms as may arise are due to com-  
plications such as pyloric or intestinal ob-  
struction ulceration hemorrhage phlegmons  
of the stomach or intestines perforative per-  
itonitis or abscess formation (bezoars large  
objects) of non passable material producing  
chronic catarrh and ulceration or forming  
granulations or inflammatory masses ob-  
structing or narrowing the lumen and the  
wandering of foreign bodies beyond the  
stomach and intestinal tract into the vagina  
bladder rectum or abdominal wall

**Diagnosis**—An accurate anamnesis is in-  
dispensable but is often misleading Pins  
coins and other objects can disappear from  
the hands or even the mouth of a baby idiot  
demented or normal adult without being  
swallowed Even bullets may be vomited or  
passed in the stool unobserved Examination  
by means of x rays both fluoroscopic and  
with films is indispensable but for the  
visualization of radiolucent objects whether  
in the stomach or in the bowel a contrast  
medium must be used A gastroscope is occa-  
sionally useful

**Treatment**—The non surgical treatment  
in cases of the swallowing of the smaller  
foreign bodies such as coins pins buttons  
and the like consists in attempting to have  
the object carried through the canal by  
bulky soft food ingested in quantity such  
as Billroth's potato purée well cooked  
spinach cabbage vegetables mineral oil or  
agar agar bread in quantity etc Contra-  
indications are symptoms of inflammation  
ulceration penetration or obturation The  
surgical treatment is required when the swal-  
lowed object is impassably large is long re-  
tained or is producing symptoms or compli-  
cations Gastroscopic removal is occasionally  
feasible in skilled hands Gastrotomy is the  
usual operative procedure There is prelimi-  
nary cleansing of the stomach by lavage and  
emptying of the fluid by aspiration A  
longitudinal incision in the stomach is made  
halfway between the greater and lesser curva-  
tures The abdominal cavity must be well  
protected from soiling by careful isolation  
with gauze packs and any remaining stom-  
ach contents must be aspirated The cut  
should be no longer than needed to permit

removal of the foreign body which previously should be located by palpation or diaphanoscopy of the stomach. Removal with instruments avoids the soiling of the hands and of the wound.

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### ACUTE PHLEGMONOUS GASTRITIS

(*Acute Suppurative Cellulitis of the Stomach Gastric Erysipelas*)

**Definition**—A phlegmon (fortunately rare) beginning usually in the gastric mucosa extending rapidly to the submucosa and to all layers of the stomach and is a rule terminating fatally from abscess formation peritonitis and other septic complications.

**Etiology**—Predisposed are the middle aged males (80 per cent) of the poor classes 25 per cent being habitual users of alcohol. The portals of entry through the mucosa may be furnished by superficial erosions in chronic gastritis achylia and corrosive poisoning by ulcer and ulcerating neoplasms by gastric wounds and operations. The causative organisms may be introduced by the swallowing of pus of buccal periodontal tonsillar or nasal origin or via the blood stream (pyemia osteomyelitis endocarditis).

Streptococci are the organisms most frequently found staphylococci and *B. coli* are less often found. In the normal stomach streptococci and *B. coli* rapidly lose their pathogenicity in the presence of free hydrochloric acid. Dogs suffer no ill effects from a diet of streptococci and glass splinters but phlegmonous gastritis develops when the mucosa is damaged with alcohol and streptococci are subsequently fed (Doehle).

**Pathology**—The gastric wall infiltrated with pus cells and inflammatory edema may be an inch thick. The swollen mucosa is thrown into thick folds and tumefactions. The submucosa shows the earliest and most intense phlegmonous changes but all layers subsequently become involved and may become indistinguishable in the general cellular infiltration and glassy diffuse edema.

There are scattered abscesses and necrotic spots of varying size and number. The surface of the stomach is covered with fibrin or pus and is more or less adherent to surrounding structures. The phlegmon usually but not always stops rather sharply at the pyloric ring and at the esophageal hiatus. Occasionally the duodenum is involved and less often the esophagus.

Suppurative peritonitis is present in 30 per cent of cases. Other complications are perigastric abscess subdiaphragmatic abscess acute suppurative pericarditis and pleurisy septicemia and pyemia.

**Varieties**—1 Diffuse extensive phlegmon with early death from toxemia and septicemia or later death from abscess formation peritonitis or pyemia. 2 Local phlegmon with localized abscess which may heal spontaneously or after surgical drainage or resection. 3 Subacute phlegmon with less necrosis and suppuration and a milder course healing with more or less extensive scarring of the gastric wall or developing into a limitis plastica often with extensive adhesions to surrounding structures.

**Symptoms**—The onset is abrupt and violent. Persistent vomiting may be the chief feature with excessive thirst severe and continuous epigastric pain and tenderness. There may be increased resistance to palpation or a palpable tender mass may be found in the epigastrium. Diffuse abdominal tenderness and rigidity with rebound phenomenon and absence of peristaltic sounds indicate complicating peritonitis. In one patient a peritonic friction rub was heard above and to the left of the navel synchronous with diaphragmatic movements and so constant as to be demonstrated to an entire class. The temperature ranges from 100° to 105° F. Chills may occur at the onset or when pyemia develops. The presence and persistence of pus in the vomitus or aspirated gastric contents usually with blood and occasionally with necrotic fragments of mucosa is very suggestive. The pyloric phlegmon often produces complete pyloric stenosis which can be shown fluoroscopically with a little barium administered orally.

**Diagnosis**—These cases are usually not diagnosed *intra vitam* unless exploratory laparotomy is performed. Perforated peptic

ulcer acute pancreatitis or acute suppurative cholecystitis is the usual diagnosis made. Suggestive of gastric phlegmon are the onset with chills and septic fever, severe acute pyloric obstruction, pain, tenderness and increased resistance to palpation localized to the epigastrium, pus and necrotic tissue in the vomitus of a middle-aged man suffering from chronic alcoholic gastritis, a chronic ulcer carcinoma or a recent gastric operation.

An acute suppurative phlegmonous duodenitis is much rarer and an independent lesion and presents a different clinical picture from phlegmonous gastritis because of the inflammatory blocking of the pylorus of Vater with obstructive jaundice and absence of the pancreatic ferments in the stools.

**Prognosis.**—The extent and virulence of the process rather than the therapy practiced determine the outcome. The acute diffuse form is almost invariably fatal whether treated by total resection, extensive tamponing or drainage. The localized and subacute forms are more likely to respond to drainage or excision. The cases in which treatment by excision is successful are likely to be diagnosed as infected neoplasm both before and at operation, their true character being discovered only upon study in the pathologic laboratory.

**Treatment.**—The excessive vomiting may be controlled by use of a Levine tube and the thirst by the administration of saline solution subcutaneously, intravenously or by proctoclysis. Since both these symptoms are usually due to pyloric obstruction, jejunostomy may be considered but seems scarcely advisable in the occasional cases in which the outcome is a matter of only a few days. An indication for gastrostomy seems questionable although a few patients have recovered following it. Probably the gastrectomized patients have recovered in spite of the operation rather than because of it. The incision and drainage of a well localized mural abscess or a perigastric abscess is distinctly helpful and essential but extensive tamponing of the whole stomach and lesser peritoneal cavity seems more provocative of peritonitis than prophylactic Sulfonamides should be administered either by mouth or by vein or by both method or penicillin may be tried.

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## GASTRIC HEMORRHAGE

### (Gastrorrrhagia Gastrorrhæxis)

**Definition.**—Gastric bleeding must not be confused with vomiting of blood (hematemesis) or passing of bloody stools (melena) whether occurring with or without the other signs of internal hemorrhage. These are symptoms of gastric hemorrhage but they are also symptoms of bleeding from other points along the alimentary tract and even the respiratory passages when blood that has been coughed up is swallowed.

**Etiology.**—The surgeon is chiefly concerned with hemorrhages so massive prolonged or frequently recurring and so unyielding to the usual medical therapy that death appears to impend unless the bleeding is quickly controlled by direct surgical attack on the bleeding point. Erosions and peptic ulcers either acute or chronic are the usual source of the bleeding. Extensive parenchymatous hemorrhages by diapedesis such as are seen with the blood dyscrasias and which infiltrate the entire wall of the stomach are not amenable to surgical relief and are best treated conservatively. Serious bleeding may occur from gastric neoplasms and from dilated veins in the lower esophagus and cardia particularly in cirrhosis of the liver but is less frequent and much less amenable to surgical control than the commoner bleeding from peptic ulcers and erosions. Particularly fatal are the deeply penetrating ulcers of the posterior wall of the duodenum which involve the head of the pancreas because of the possibility of erosion into a branch of the superior pancreaticoduodenal artery.

**Pathology.**—At operation and even at autopsy it may be difficult to discover the source of the hemorrhage if bleeding has

stopped temporarily. Even in an old caloused ulcer where the dense fibrous tissue prevents the bleeding artery from retracting or collapsing the tiny orifice may be invisible unless it continues to bleed or is filled with a protruding clot. Still less easily visible is the open vessel in an acute ulcer because here it can both retract and collapse. Acute gastric catarrh is a frequent accompaniment of gastric hemorrhage and probably has some etiologic relationship to it. It is more frequent in the acute than in the chronic ulcer.

**Symptoms**—Hematemesis and melena are the most frequent and obvious signs of gastric hemorrhage but they may be either preceded or followed by signs of severe internal hemorrhage: *e.*, dyspnea, thirst, pallor, vertigo, prostration or collapse, weak thready pulse and lowering of the blood pressure, hemoglobin content and erythrocyte count.

With these symptoms presented by a patient known to have a chronic or recurring ulcer it is a reasonably safe presumption that the hemorrhage comes from the ulcer. Where a history of pre-existent ulcer is lacking determination of the source of bleeding may require considerable time and effort just when both of these factors are precious. Filling of the stomach with a barium meal for fluoroscopic purposes may start up bleeding afresh or may cause an acute ulcer to perforate. Ulcer craters and tumors can usually be seen with the x-ray but acute ulcers can rarely be seen. The presence of an ulcer crater or a tumor in the stomach is presumptive although not positive proof that the lesion visualized is the source of the bleeding.

**Diagnosis**—For surgical purposes it is necessary to know (1) that the bleeding is from the stomach, duodenum or intestine and is not from the esophagus, mouth, throat or lungs; (2) that the lesion from which the bleeding is coming is amenable to operation in contradistinction to parenchymatous hemorrhage, inoperable cancer or dilated veins accompanying cirrhosis of the liver; (3) whether the hemorrhage is continuing and at what rate and how much blood has been lost; and (4) where in the stomach the bleeding point lies so that it may be promptly found at operation and so

that no unnecessarily large incision in the stomach or prolonged hunting under anesthesia will be required.

When copious melena or hematemesis or both occur and the patient is known to have gastric ulcer it is reasonably safe for practical purposes to assume that an ulcer is the site of the hemorrhage provided always that careful examination of the patient reveals no other source of hemorrhage. The patient's general symptoms, blood pressure, pulse rate, blood examination and the amount of blood vomited and passed in the stools are the only criteria for determining how much the patient has bled and whether bleeding is continuing. Therefore only a rough clinical estimate can be made. Abdominal auscultation in a case of bleeding ulcer reveals the peristaltic sounds as loud, vigorous and continuous as after a full meal in marked contrast to intraperitoneal hemorrhage which always diminishes and often abolishes peristaltic murmurs. When the ulcer stops bleeding the sounds fade away to the faintness and infrequency of the fasting state until the diet is resumed.

The site of the ulcer may be known from previous x-ray examination. Otherwise a midline laparotomy incision will expose the stomach and the stomach wall can then be explored by hand, eye and diaphanoscopy (Rovsing). The interior of the stomach may be explored with the Rovsing gastroscope, an instrument which is similar to a single catheterizing cystoscope and the latter as well as the observation cystoscope has been used in place of the Rovsing instrument when that tool was not available. Rovsing's instrument is preferable however because of its wider field of vision which allows more rapid and certain inspection of the interior of the air-distended stomach. Moreover it has a larger light which is better for diaphanoscopy. The instrument is introduced through a small incision in the anterior wall after aspiration of the stomach contents with a purse string suture to prevent leakage of the content. The interior of the stomach is then examined by means of the instrument much as an air-filled urinary bladder is examined with a cystoscope.

**Prognosis**—Even in severe and protracted hemorrhages the outlook for life is relatively good. As the blood pressure drops



with the Rovsing gastroscope or if no apparatus is available by direct inspection with the eye through a long anterior incision midway between the two curvatures. It should be borne in mind that a gastric ulcer usually lies along the lesser curvature and a bleeding duodenal ulcer on the posterior wall near the pancreas.

It is the test of a master surgeon to detect the correct time for intervention and to choose and execute the needed procedure after accurately locating the bleeding point. His choice has a wide range and includes simply backing out from parenchymatous hemorrhage, ligation or suture with or without packing of a bleeding point, underpinning sutures, ulcer inversion, ulcer excision with knife or cautery and with gastric or duodenal mobilization, pyloroplasty, gastrojejunostomy or gastric resection. (See the chapter on Gastric Surgery.) Resection carries in general the greatest operative risk but offers the most permanent cure especially of the large calloused ulcer.

When no ulcer or definite bleeding point is found on exploratory laparotomy, splenectomy has been performed with some apparent benefit in a few cases. However, it can not yet be considered a standard procedure.

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#### GASTRIC WOUNDS

**Etiology and Pathology.**—Wounds of the stomach are usually classified as open or penetrating and closed or subcutaneous depending on whether or not the abdominal wall is penetrated or ruptured at the time of injury. *Penetrating wounds* are those caused by missiles usually gunshots, stabs

from knives and other sharp instruments and deep lacerations from machinery moving vehicles falls against sharp objects and the like. *Subcutaneous wounds* are caused by blunt traumas such as blows, kicks, falls, automobile accidents, etc. A fully distended stomach, particularly if weakened by chronic alcoholism, scars or disease, may burst from a blunt injury insufficient to tear a collapsed stomach. In general, however, the stomach is tougher than the bowel, is somewhat protected by the ribs, particularly when it is empty, and is then less liable to blunt injury than is the bowel, liver or spleen.

The stomach when distended after meals or drinking bouts is particularly vulnerable to knife wounds, not only because of its increased size but also because it cannot yield or slip aside from the blade as readily as the small bowel, since it has no mesentery and since it lies directly against the rigid spinal column behind and the relatively unyielding liver and diaphragm above.

Subcutaneous rupture of the stomach from over distention by drink, gas (Sedlitz powders) or instrumentation (stomich tube gastroscope) is seen almost exclusively in stomachs friable from local disease. The same holds true for ruptures occurring after heavy lifting or excessive vomiting.

Laceration of the stomach by blunt violence (kicks and falls) is due to crushing against the spinal column. Even when the stomach is not perforated by the injury, peritonitis may ensue from suppuration of the mural hematoma or because the crushing is sufficient to make the wall permeable to pyogenic bacteria, even though not actually gangrenous. The liver or spleen is usually crushed at the same time since they are both more vulnerable to crushing accidents than is the stomach. The pancreas and duodenum are less liable to injury.

Bursting lesions are usually in the form of longitudinal tears which tend to parallel the lesser curvature. The immediate flooding of the peritoneum with gastric contents and blood is so rapidly fatal that this rather rare lesion is seen more often by the pathologist than by the surgeon. It is extremely doubtful that the stomach is ever ruptured by voluntary contraction of the abdominal muscles as in straining or lifting unless it is both friable from disease and distended.

Rarely do gunshot or revolver wounds of civilian life show the bursting effect on the stomach that has been noted by military surgeons. Even in war wounds it is infrequent as compared with the bursting effect of high velocity war missiles on the distended bladder and the brain. The small caliber and low velocity of the projectiles explain the relative absence of this phenomenon in civilian practice.

**Symptomatology and Diagnosis.**—The clinical picture of gastric injuries cannot be separated from that of abdominal wounds in general. The initial symptoms are those of hemorrhage and shock. Fat embolism is likely to occur when subcutaneous fat has been lacerated and crushed or bones have been broken. Hemorrhage is invariably present and the degree of shock usually varies roughly with the amount of blood lost. It is unfortunate that methods of measuring the amount of blood lost following injuries are so inaccurate that one seldom can be quite certain that the symptoms of so-called shock noted in an injured patient may not be due to loss of blood alone.

The diagnosis of perforating wound of the stomach is usually easy. An external wound is seen. The appearance of the wound and the patient's anamnesis indicate the nature of the weapon used. In gunshot injuries a wound of exit is looked for in addition to the wound of entrance or the flat of the hand is passed carefully over the skin on the opposite side of the body hunting for the spent bullet which often stops just beneath the skin. Pressure on the bullet if found elicits a point of tenderness. If not found by the hand it can be located with ease fluoroscopically, marks being made on the surface of the skin to indicate the location. A line connecting the bullet with the wound of entrance will indicate the path of the bullet through the body with admirable exactitude and a good anatomic atlas will indicate which organs have been penetrated. It is a common delusion that bullets bounce or curve in their path through the body as around ribs for instance. The fact is that when the course of the bullet deviates from a straight line its velocity is gone and it is no longer able to penetrate the tissues of the body to any material extent.

Allowance must be made for the fact that

the stomach and other mobile viscera lie somewhat lower in the abdomen in the standing than in the supine posture and that the stomach lies higher in fat persons than in thin. If the bullet's trajectory passes through or close to the normal position of the stomach a stomach tube is passed and the gastric contents are aspirated and examined for blood. Fluoroscopy may be used if there is enough air or fluid in the stomach to outline it and one can sight along the bullet's trajectory that is from the wound of entrance to the location of the bullet and see its relation to the stomach. If air has escaped from the stomach into the peritoneum it will be easily visible in the fluoroscope as it changes its location in the peritoneum with change of position of the patient. Pneumoperitoneum indicates perforation of a hollow gas-containing viscus and if the line of the trajectory runs through the stomach it is logical to assume that the gas seen comes from the stomach. A perforating wound of the large bowel may also produce an almost immediate pneumoperitoneum but a wound of the small bowel usually does not lead to pneumoperitoneum until at least twenty-four hours has elapsed that is until there has been sufficient time for peritonitis to develop with gaseous distention of the small bowel.

In cases of stab wound inspection and probing often indicate its probable course and depth and also may fail to do so. The size and length of the weapon if known are some indication of the limits of penetration. There will usually be blood in the perforated stomach and an artificial pneumoperitoneum though seldom indicated can be produced as with gunshot wounds by inflating the well aspirated stomach with a Levine tube. A spontaneous pneumoperitoneum is not always present. In the case of a silent tense abdomen the presence of tenderness beyond the limits of the apparent wound requires surgical exploration even when probing fails to reveal penetration through the abdominal wall.

The stomach is rarely ruptured by blunt violence. Blunt injury sufficient to rupture the stomach is usually sufficient to rupture the liver, spleen or other abdominal viscera at the same time. Together with the specific signs and symptoms of gastric perforation

previously noted there are the general symptoms of perforation of an abdominal hollow viscus namely local pain and tenderness which gradually spread a silent rigid abdomen obstipation and nausea. From twelve to twenty four hours later as peritonitis sets in fever leukocytosis diffuse tenderness with rigidity and increasing meteorism develop. Thus the diagnosis of a perforated viscus becomes easily evident when operative or other therapy has become relatively hopeless.

**Complications**—The complications in general are those of injuries of the upper abdomen. The liver gallbladder spleen pancreas and large and small bowel may be injured simultaneously. A particularly difficult chapter of abdominal surgery is that of wounds involving the stomach diaphragm and organs of the chest especially on the left side. These are the so called thoraco-abdominal wounds of the left upper quadrant. They may involve the liver spleen and splenic flexure of the colon as well as the stomach lung pleura and diaphragm.

Gunshots and stabs of the back below the level of the sixth rib on the left side are liable to penetrate the abdomen as well as the chest and must always be examined with that possibility in mind. Roentgen examination is of great value here in early diagnosis negative findings being almost as conclusive as positive findings.

The postoperative complications of gastric perforations are much like the postoperative complications of abdominal injuries in general chiefly hemorrhage and infection and their sequelae.

**Prognosis**—The prognosis depends on the character of the injury of the stomach and of the other abdominal viscera the amount of hemorrhage and infection the number of wounds the nature of the complications and the patient's general condition on admission to the hospital. Delay in seeking competent surgical aid is a serious and often fatal error.

Single small and not deeply penetrating wounds without complications which are promptly repaired by operation usually offer an excellent prognosis. Extensive multiple large and neglected wounds and their complications are associated with a high mortality rate.

**Treatment**—The management and surgical indications of gastric injuries can scarcely be considered apart from the injuries of the other abdominal viscera.

Penetrating injuries of the stomach must be repaired promptly by operation or the patient will die from hemorrhage or from peritonitis due to leakage. But a patient in shock with a feeble pulse cold hands and feet a sweating brow a blood pressure below 90 systolic and a low hemoglobin value and red cell count if operated on immediately will usually succumb on the table or shortly thereafter unless blood or plasma is available in generous quantity. The patient should first be made comfortable by morphine given intravenously (same dosage as for hypodermic administration). The stomach is aspirated and a Levine tube left in. No lavage is permitted. A snug scultetus binder is applied to the abdomen as soon as the morphine is effective. The binder reduces but does not always control venous hemorrhage and gastric leakage. It has still less control over arterial hemorrhage. Intravenous administration of electrolyte solutions is contraindicated (lest the clotting time be diminished and existing clots displaced by increasing blood pressure) until all hemorrhage has been controlled with certainty usually at operation. A blood plasma drip is started at once and is followed by citrated or heparinized blood as soon as the patient's blood can be typed and matched. The transfusion is continued while the patient is being wheeled to the operating room and during the operation during his return to bed and after he is in bed until the values for blood pressure red blood cells and blood protein have returned to approximately normal.

Until he is on the operating table the patient should be kept in the position in which the gastric wound is least likely to leak i.e. on the left side for a pyloric wound and on the right side for a wound of the cardia. If the systolic pressure rises quickly to 100 mm. the patient is probably a good operative risk. Patients known to have a normally high pressure must have the preoperative pressure raised accordingly.

These preparatory and stimulatory measures are practically the same as for other wounds of the abdomen and therefore will not be treated in further detail here.

Those surgeons who have whole blood and blood plasma easily and immediately available in large amounts from a blood bank need pay much less attention to the initial blood pressure and to preliminary shock therapy than has been necessary in the past. The blood pressure can be built up even at the operating table and 'secondary shock' noted after the use of saline and dextrose solution practically disappears. Optimists go so far as to prophesy that immediate operation soon will be the rule in most cases of abdominal injury except when the patient is moribund.

The operation may be started under local anesthesia with morphine and scopolamine and as little ethylene ether or nitrous oxide and oxygen used subsequently as possible. Spinal anesthesia is time consuming and tends to lower an already too low blood pressure.

For a bullet wound the incision should be either midline paramedian on the side of the injury or transverse. Knife wounds are usually best explored by enlarging the wounds of entrance by a more or less muscle splitting procedure. Generous incisions shorten these operations, make careful explorations easy, avoid excessive and painful pulling on the stomach or other viscera and permit a careful and effective abdominal toilet. When local anesthesia is used the peritoneum about the margins of the incision should be anesthetized by subperitoneal injection before wound retractors are applied, preferably self-retaining retractors. The anterior gastric wound is immediately closed by two or three layers of suture, the first of silk or linen and the second of catgut. Lambert suture.

In cases of gunshot wounds it is even more important to find and close the wound on the posterior surface of the stomach than that on the anterior, because the former usually is larger and more likely to leak during subsequent dorsal posture. In the presence of an anterior wound it should always be assumed that there is a wound of exit elsewhere in the stomach (or rarely duodenum or esophagus). The failure to find it means a fatality if it is present. Single grazing wounds of the stomach are rare as compared with grazings of the small bowel. The same bullet in certain circumstances especially trans-

verse wounds may produce three or even four separate gastric perforations. A stab wound is usually single but may perforate through and through and may even be multiple.

At least two Lambert purse string or Z stitches should be used on each stomach perforation whereas a single stitch may often suffice for the small bowel. There is little likelihood of dangerous narrowing of the gastric lumen by two or even three layers of stitches while in the small bowel stenosis is much more of a liability.

The catching and ligating of bleeding points is usually the first step and the closure of the perforations the second. The electric aspirator is used to suck up the free fluid and blood in the peritoneal cavity and gauze packs placed beyond the field of operation tend to complete the drying process while the perforations are being closed. If much partly digested food is present in the peritoneum it is difficult to remove it completely either with forceps aspirator or packs. The patient's general condition must determine how long a time may be spent in the effort to remove all food particles. It is doubtful if any kind of subsequent drainage of the abdomen is particularly effective either in avoiding or limiting subsequent peritonitis.

*Thoracoabdominal wounds* perforating the diaphragm are difficult to explore and repair particularly on the left side. Gunshot wounds are usually attacked best from an abdominal incision since the principal lesions are below the diaphragm and the diaphragmatic perforation can be closed from below. Stab wounds are best managed by enlarging them and exploring them to the bottom. For better exposure the adjacent ribs may be spread or one rib (rarely more) resected. With only a small cut in the skin there may be a long cut in the diaphragm with the stomach herniating through it and the contents leaking into the pleural cavity. The stomach may so plug the hole in the diaphragm that no appreciable leakage takes place into the abdomen even after twenty-four hours or the abdominal extravasation may be extensive.

The hole in the stomach is sutured, the bleeding omentum is ligated and stomach and omentum are returned to the abdomen. Stick sponges may be introduced into the

upper abdomen both in front of and behind the stomach to determine the presence of extravasated gastric contents or blood. If further abdominal exploration is indicated an upper abdominal laparotomy also is necessary.

The electric aspirator and stick sponges are used to clean and dry the pleural cavity before the stomach and omentum are reduced. The cut in the diaphragm is sutured and a catheter sewed into the chest wound for closed drainage. If the pleura is not soiled by gastric leakage the chest wall is closed tightly, the pneumothorax aspirated immediately by needle or trocar and the puncture opening sealed.

The combined thoracoabdominal operation consumes much time in the approach, the internal exploration and repair and the closure. It has a high mortality around 50 per cent. The anterior osteoplastic flap operation on the lower left ribs gives good exposure of the structures in the left upper quadrant and of the diaphragm but is tedious and bloody, has a similar high mortality and occasionally a suppurative osteochondritis as a sequel. For small caliber wounds of the lung, diaphragm and upper cardiac portion of stomach where injury to the spleen and splenic flexure of the colon can be ruled out safely (fluoroscopic determination of the course of the bullet in relation to the gas-filled splenic flexure and the splenic shadow) the writer has used non-operative management in 12 cases with only 1 death and 2 subphrenic abscesses which healed after subsequent surgical drainage. In these cases the stomach is aspirated. Levine tube continuous drainage is started and the patient is turned in bed and kept on the right side so that all gastric contents will gravitate to the pars pylorica from which the Levine tube will aspirate it. All ingesta are withheld for at least a week.

The postoperative treatment of patients with gastric wounds differs but little in general from that of patients with abdominal wounds. Nothing is given by mouth for at least three or four days. During the first week the Levine tube is used almost continuously. The patient is supported by means of saline and dextrose solution administered subcutaneously or intravenously or both. Proctoclisis may be used subsequently when

the colon is known to be intact. Intravenous transfusion must not be given in amounts large enough to overload the heart muscle or to disturb the ionic balance of the blood plasma.

The subsequent treatment of symptoms and complications is about the same as in cases of other abdominal wounds. Fowler's position is not desirable since it tends to allow perigastric inflammation to spread downward. Perigastric and subdiaphragmatic abscesses which may develop subsequently require early diagnosis and evacuation. Intraperitoneal drains inserted at the primary operation are of doubtful value.

ROGER T. VAUGHAN

## GASTRIC ULCER

**Definition.**—The term *gastric ulcer* implies a defect in the mucosa of the stomach with or without extension of the process to the deeper layers of the gastric wall. There are two distinct groups of gastric ulcers: (1) acute ulcers which are usually superficial and which tend to heal spontaneously and (2) chronic ulcers which are of long standing and which seldom heal without treatment. By far the more important group from the clinical standpoint is that of chronic ulcers.

**Acute Gastric Ulcer.**—Acute gastric ulcers may result from local trauma or may be part of a generalized process such as burn, uremia or arteriosclerosis (Fig. 530 B). The ulcers vary from a millimeter to several centimeters in diameter. They tend to be multiple and superficial. If they are not a part of a generalized condition which is in itself fatal, these ulcers usually heal rapidly and seldom require surgical intervention.

**Chronic Gastric Ulcer.**—The clinical problems connected with ulcer of the stomach are largely confined to the chronic type. In the remainder of the discussion the term gastric ulcer when used without qualification is understood to refer to chronic gastric ulcer. This lesion is closely related in most respects to duodenal ulcer. Although the two are probably caused by a common etiologic factor or factors and are similar in symptoms and in response to medical treatment, they differ widely in problems of dif-

ferential diagnosis and in surgical considerations. The greatest difference lies in the fact that ulcerations of the duodenum are very seldom malignant whereas the possibility of malignant disease must be kept constantly in mind in dealing with ulcerations of the stomach.

**Incidence.**—The incidence of gastric ulcer is greater in the races of Europe and the United States than it is among primitive peoples. It is probable that about 10 per cent of the population of Germany, France, Great Britain and the United States have at some time a chronic ulceration of the upper portion of the gastrointestinal tract. Although postmortem studies have shown an almost equal frequency of gastric and of duodenal ulcer, the latter appears to be encoun-

amount of free hydrochloric acid in the gastric contents has long been considered a probable factor in the production of gastric ulcer. Its presence seems to be essential not only to the formation of the lesion but especially to its chronicity. Moreover control of the acidity by various types of medication leads to relief of symptoms and subsequent healing of the ulcer. However ulcers usually do not occur in those areas of the stomach which are richest in acid secreting cells. Although the acid factor seems definitely related to the persistence of a gastric ulcer it is not sufficient to account for the onset of the lesion.

2 **Trauma.**—Trauma of itself does not lead to chronic gastric ulcer. Surgical defects in the stomach heal readily and be-

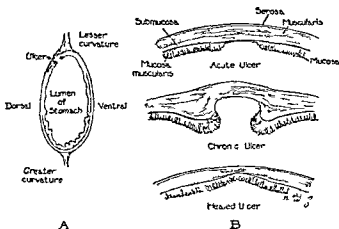


Fig 530—1 Diagrammatic cross section of the stomach showing the common location of a gastric ulcer on the lesser curvature. B Schematic sections of the stomach wall showing acute, chronic and healed gastric ulcers.

tered much more often by the clinician. The estimates range from 1:4 to 1:14.<sup>5</sup> Gastric ulcer occurs four times as often in men as in women. It may develop at any age but reaches its peak between the ages of thirty and fifty.

**Etiology.**—The many theories which have been suggested as to the underlying cause of gastric ulcer indicate by their very number that the exact etiologic factor is unknown. It is possible that several factors may operate to produce the same end result and that a chronic indurated ulcer may result from different processes in different individuals. Of the possible factors which have been suggested the ones presented here seem most worthy of attention at the present time.

1 **Acid Factor.**—The presence of a large

have more like acute gastric ulcers. On the other hand trauma may operate in conjunction with other factors to produce the chronic type of lesion. The fact that the majority of gastric ulcers occur along the lesser curvature and in the antrum of the stomach suggests that the mechanical action of the stomach, which forces the gastric contents against the stomach wall at this point, may play a role in ulcer formation.

In experimental studies artificially produced gastric ulcers on the lesser curvature heal more slowly than those on the greater curvature. Similarly the healing of defects produced by excision of portions of gastric mucosa is greatly retarded if a rough diet is given. This again suggests that trauma is an important secondary factor in the forma-

tion of gastric ulcer but that in itself it is not sufficient to initiate these lesions. The experimental observations have a direct clinical correlation because they are in accord with the beneficial results obtained with bland diet in the medical treatment of gastric ulcer as well as in the postoperative care of patients who have had an operation for gastric ulcer.

**3 Vascular Factor**—According to some authorities lesions of the submucosal vessels are of significance in the production of chronic ulcerations of the gastric mucosa. If these lesions have a definite bearing on the production of chronic ulcers it should be possible to find them in surgical specimens or at autopsy in a large percentage of cases. However the thrombi and lesions of blood vessel walls occasionally seen in the neighborhood of gastric ulcers are in general to be regarded as the result of secondary changes in the area of the lesion. It is possible however that a state of long continued vascular spasm may have some relation to the production of gastric ulcer.

**4 Neurogenic Factor**—There is a strong clinical impression that severe nervous and emotional strain bears a direct relation to the onset of gastric ulcer in many patients. Furthermore the mental status of a patient with known gastric ulcer has an important bearing on his improvement under treatment. Recurrences are very frequently correlated with the repetition of severe emotional strain. These clinical observations have led to extensive consideration of the etiologic relationships between neurogenic factors and the development and persistence of gastric ulcers. This relationship was clearly stated by Rokitsansky and was revived in more recent years by Cushing.<sup>3</sup> Cushing pointed out the frequency of the development of acute peptic ulcers in lesions of the interbrain and produced strong arguments in favor of the relationship of neurogenic factors and gastric ulcer. None of these studies however clearly elucidated the specific mechanism by which the neurogenic influences lead to the production of chronic gastric ulcer. It is possible that neurogenic factors produce long repeated or continuous spasm of the blood vessels with resulting necrosis of the mucosa. It is possible also to assume that the blood vessels

are constricted by spasm of the surrounding musculature. In either case there might be no demonstrable change in the vessels as seen at postmortem examination or in the resected surgical material. For this reason the neurogenic factor offers a possible but as yet incompletely demonstrated basis for the etiology of gastric and duodenal ulcer.

**5 Miscellaneous Factors**—Numerous other factors have been suggested as responsible for the formation of gastric ulcer but thus far clearest experimental and clinical evidence has not been forthcoming. Infection by itself is almost certainly not a cause of ulcer but the onset or recurrence of the symptoms of gastric ulcer may coincide with an acute infection. The unsatisfactory physical condition of a patient which accompanies such infection might appear to be the element involved rather than the infection itself.

Endocrine factors may influence the formation of gastric ulcer. Ivy<sup>7</sup> has put forward evidence for the possible relation of several hormones especially enterogastrone to the development of gastric ulcer. The role of these various gastrointestinal hormones in the production of chronic gastric ulcer has not been completely elucidated but the investigation of these hormones offers an important field for study.

**Pathology**—Chronic gastric ulcers are located in the majority of instances along the lesser curvature about the incisura angularis and in the prepyloric region (Fig 530 A). Some of them are round while others are ovoid with the long axis transverse to the long axis of the stomach.

A typical gastric ulcer shows a defect in the mucosa which may vary in diameter from a few millimeters to several centimeters. The glands of this layer are hyperplastic at the edges of the defect. The margins of the ulcer tend to be undermined and to extend beyond the region at which the mucosa is interrupted (Fig 530 B). The submucosa is also eroded and in most instances the ulceration extends for a distance into the muscularis. The edges of the ulceration are made up of scar tissue. Part of it is composed of old collagenous connective tissue indicating that the process has been going on over a considerable period of time. Other portions show actively proliferating

fibroblasts and blood vessels indicating that the process of repair has continued up until the time of examination. The process therefore represents the repair of a long continued injury.

If there are large vessels close by they sometimes show moderate thickening of their walls. Rarely thrombi are observed but there are no constant vascular lesions about the ulcer. The presence of large vessels in the region of these ulcerations is important because they may become eroded with consequent hemorrhage.

Perforations result from continued penetration through the wall and the serosa. However penetration may be so deep even without perforation that the roentgenogram suggests a diverticulum. The depth of the gastric ulcer as seen in roentgenograms is considerably increased by the amount of edema about the lesion. The rapid diminution in size of the filling defect when treatment has been instituted is largely a result of the disappearance of this edema.

A considerable amount of scar tissue is produced in the healing of gastric ulcers especially if they are large. With the contraction of the scar tissue deformity of the stomach results. When this occurs near the center of the stomach an hourglass constriction is formed (Fig 531) if it takes place in the prepyloric region narrowing of the pylorus is the result. When the degree of constriction is great enough to interfere with the passage of food there is hypertrophy of the musculature proximal to the region of obstruction.

The inflammatory reaction which surrounds the ulcer leads to considerable induration especially when fat tissue has become necrotic. This reaction is difficult to distinguish from a malignant lesion especially when the specimen is studied only in the gross.

In making a microscopic examination of a gastric ulcer it is important to examine many portions of the lesion before it is stated definitely that malignant disease is absent. Now that earlier examples of gastric ulcer are discovered as a result of the improvement in roentgenographic diagnosis the pathologist sees a greater number of small lesions which contain evidence of early malignant growth. Mallory<sup>8</sup> described a

series in which the lesion was so early that even microscopically it was difficult to decide whether the condition was definitely carcinomatous or not. By securing such lesions for study progress can be made in understanding the pathogenesis of these lesions and more successful treatment can be instituted.

**Symptoms.**—The symptoms of gastric ulcer are so variable that a classic syndrome can hardly be defined. Indigestion and epigastric pain are the most frequent complaints. Indigestion is interpreted differently by each patient and may be described as a feeling of hunger, fullness or burning or a gnawing sensation associated with heart burn and sour eructations. The distress is

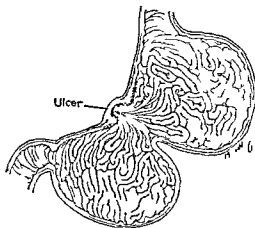


Fig 531—Central constriction associated with a chronic gastric ulcer of long standing producing hourglass constriction of a B. stomach.

usually relieved temporarily by the taking of food or alkalis but recurs within one to two hours after meals. Frequently the symptoms last for years with intermittent periods of relative freedom from distress. Periodicity is far less common with gastric than with duodenal ulcer. The periodicity is explained by the fact that ulcer is a chronic disease which tends to recur from time to time owing to such predisposing factors as indiscretions in diet, worry, fatigue and infection.

The pain varies from a dull gnawing sensation in the epigastrium to a severe stabbing pain depending upon the location of the ulcer and the degree of penetration. A posterior penetrating ulcer commonly produces pain which is referred to the back. If



perigastritis is present about the ulcer the pain may be aggravated by eating.

Bizarre symptoms may be present owing to interference with the motor function of the stomach. Vomiting and difficulty in swallowing may result from cardiospasm when the ulcer is high in the stomach. Vomiting with signs of pyloric obstruction may be present owing to pylorospasm or deformity caused by an ulcer in the prepyloric region. Symptoms of obstruction may appear as a result of the development of an hourglass constriction of the stomach. These secondary effects of the ulcer may bring about a confusing clinical picture.

**Physical Signs**—The patient with gastric ulcer may or may not show positive physical signs depending upon the location of the ulcer and the possibility of an associated complication. Rigidity and tenderness of varying degrees may be present in the epigastrium when the ulcer is active and penetrating. These findings are more marked when the patient is having pain from the ulcer. When there is marked interference with the normal motor function of the stomach the patient may show considerable weight loss and dehydration from inability to take or retain food.

While the physical examination offers little evidence to substantiate the diagnosis of gastric ulcer it must not be slighted for it may disclose definite information as to the degree of penetration or as to possible complications or it may disclose other sources of disease which produce symptoms mimicking those of gastric ulcer.

**Special Examination**—1 *Gastric Analysis*—There is no specific finding by gastric analysis which is diagnostic of gastric ulcer. However from gastric analysis information may be obtained which is of value in the treatment of the ulcer and is possibly an aid in the differential diagnosis from carcinoma. The concentration of hydrochloric acid in gastric secretions averages about 30 per cent above that of the normal person.<sup>6</sup> A progress in lowering of the acidity at intervals of three weeks suggests that the ulceration is malignant. Absence of free hydrochloric acid usually indicates the presence of carcinoma rather than of benign ulceration.

Occult blood if present in several gastric analyses implies an active ulcer or car-

cinoma. However it often happens that an occasional positive reaction for blood is obtained as a result of trauma during aspiration.

2 *Stool Examination*—Examination of a stool specimen for occult blood should be made routinely. The persistent finding of occult blood when the patient is under treatment should raise the question of malignant disease.

3 *Roentgenologic Examination*—Roentgenologic examination is undoubtedly the most valuable diagnostic aid available today to the physician because it not only confirms the presence of an ulcer but it discloses the exact size and location of the lesion. In addition it gives a relative idea of the activity of the ulcer and the response to subsequent medical treatment. Most important of all it helps to differentiate between a benign lesion of the stomach and carcinoma.

Gastric ulcers along the lesser curvature characteristically show a diverticulum like projection of barium which is known as a niche (Fig 53<sup>2</sup>). This outlined pocket projects beyond the normal limit of the gastric wall as a result of the penetration of the ulcer and the edema of the adjacent mucosa and submucosa. The rugae adjacent to the ulcer are frequently accentuated and may converge toward the crater. Peristalsis is present up to and below the ulceration unless there is penetration of the ulcer with surrounding induration and fixation. The ulcer crater is usually tender to palpation. Opposite such an ulceration may be a spastic contracture (incisura) of the greater curvature. Occasionally in a chronic ulcer of long duration the greater curvature is drawn toward the ulcer by scarring thereby dividing the stomach into two parts and producing the so called hourglass deformity, or B stomach (Fig 51<sup>1</sup>).

In contrast to the diverticulum like appearance of benign ulcers malignant ulcers are usually shallow irregular and crater like in appearance without tenderness to palpation. They are frequently larger than benign ulcers as a result of the central necrosis. If there are slight irregularities about the margin from tumor masses the diagnosis of carcinoma is established. In carcinoma the peristaltic waves are obliterated and fre-

quently the mucosal pattern about the ulceration is distorted owing to infiltration of the tumor

The roentgenologic examination also shows the amount of retention following the six hour meal of barium. Since gastric ulcers produce changes in the gastric physiology a moderate amount of barium retention commonly occurs as a result of interference with gastric motility. Repeated fluoroscopic studies give information as to the effectiveness of medical treatment in controlling the retention.

Investigation establishes whether the lesion is benign or malignant when other methods of investigation are not sufficient to make this differentiation and at a time when successful treatment may be instituted.

**Differential Diagnosis**—Since the symptoms of gastric ulcer are so variable it is often difficult to differentiate ulcer from many other lesions both within and without the gastrointestinal tract.

Chronic cholecystitis may produce symptoms simulating those of gastric ulcer but the location and radiation of the pain in gall

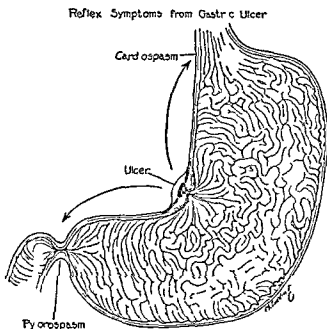


Fig. 532.—Diagram showing the configuration of a gastric ulcer. The deep base and relatively narrow neck of the ulcer crater when filled with barium give the appearance of a diverticulum in the roentgenogram. This diagram also shows the reflex symptoms at the cardia or the pylorus produced by a gastric ulcer.

The primary consideration of the roentgenologist then is two fold. He must confirm the clinician's impression of gastric ulcer and determine as soon as he can whether the ulceration has any of the characteristics of carcinoma. The roentgenologic examination should be repeated after three weeks of medical treatment.

**4 Gastroscopy**—The gastroscope allows actual visualization of the stomach wall. Its use as a diagnostic procedure in cases in which roentgenologic examination leaves some doubt has become increasingly important. By means of this procedure the lesion can be visualized and material secured for biopsy. In many instances this method of

bladder disease together with the aggravation of symptoms by the ingestion of fried and fatty foods should suggest gallbladder disease. If not the physical and roentgenologic examination of the stomach and gallbladder should clarify the diagnosis.

Inflammatory lesions involving the terminal ileum, appendix or right colon are known to produce symptoms referable to the epigastrium similar to those of gastric ulcer. However, absence of relief by food and antacids as well as the presence of pain and tenderness in the right lower quadrant should focus attention on this area. Likewise symptoms of carcinoma of the right colon may be similar to those of gastric

ulcer The existence of such lesions in addition to gastric ulcer should not be overlooked

Gastritis without ulceration does not give a typical ulcer syndrome and the symptoms may be exaggerated rather than relieved by the taking of food Here again roentgenologic and gastroscopic examination give invaluable aid in making the diagnosis A gastric crisis due to syphilis may simulate that due to a gastric ulcer but this is a rare occurrence It should be borne in mind that syphilitic patients may also have gastric ulcer Free hydrochloric acid is frequently absent in the presence of gastric syphilis

Reflex symptoms from other systems such as the genitourinary and nervous systems may be confused with those of ulcer While the periodicity of ulcer symptoms combined with the temporary alleviation of the complaint following the taking of antacids and food may suggest the diagnosis of gastric ulcer the final diagnosis invariably depends upon the roentgenologic examination with barium

The symptoms of gastric and duodenal ulcer are so similar that a differential diagnosis is frequently impossible from the history and physical findings A shorter period of relief after meals usually follows in the presence of gastric ulcer but this is not an infallible guide The point of maximum tenderness in the upper abdomen may give a clue to the location of the ulcer Patients with gastric ulcer are on the average ten years older than those with duodenal ulcer Because of the danger of carcinoma associated with gastric ulcerations the diagnosis of gastric ulcer should not be delayed while diet and medication are tried but should be made immediately by roentgenograms

Once it has been determined that there is ulceration of the gastric mucosa the clinician must decide if possible whether the lesion is benign or malignant Since approximately a third of the patients with carcinoma of the stomach give a history consistent with gastric ulcer in all respects including temporary improvement from diet and medication the only safe attitude to assume is that any gastric ulcer is potentially malignant until proved otherwise

It is sometimes impossible to determine by the various laboratory examinations in-

cluding roentgenographic study whether a small gastric ulcer is benign or malignant until its response to medical treatment has been determined The problem is all the more difficult because over one third of the patients with carcinoma have a normal gastric acidity and some show a temporary decrease in the size of the ulceration following medical treatment The complete disappearance of a small carcinomatous lesion in the roentgenogram is rare but may occur

Certain criteria have been established to aid in differentiation depending upon the location and size of the ulcer as well as the response to medical treatment Gastric ulcerations in the prepyloric region have a three out of four chance of being malignant<sup>8</sup> This is especially true of those located in the 2.5 cm of stomach adjacent to the pylorus<sup>9</sup> Ulcerations along the greater curvature are practically always due to carcinoma Similarly large ulcerations that is those over 3 cm in diameter are considered potentially malignant If by fluoroscopic examination the gastric ulcer is found to have any of the characteristics suggestive of neoplasm a second examination should be made after three weeks of medical treatment Gastroscopic study may be helpful in making an early diagnosis of carcinoma in these borderline lesions In such cases strict medical treatment including bed rest is prescribed for a period of three weeks

Scott and Mider<sup>10</sup> have advocated resection of a gastric ulcer which does not respond to strict medical management as demonstrated by a diminution of symptoms and occult blood in the stool the second week and the disappearance of the filling defect noted fluoroscopically by the end of the third week A very large ulcer should decrease in size by at least one third after three weeks of medical treatment The menace of cancer requires constant vigilance since there is more or less general agreement that 5 to 10 per cent of all gastric ulcers become malignant

**Complications**—The majority of gastric ulcers respond satisfactorily to medical treatment however the complications of gastric ulcer often require surgical intervention The common complications of gastric ulcer are hemorrhage perforation and obstruction

1 **Hemorrhage**—Bleeding occurs in about

10 to 20 per cent of all cases of gastric ulcer at some time during the course of the disease.<sup>11</sup> An ulceration along the lesser curvature may penetrate and erode one of the larger vessels causing serious hemorrhage (Fig 533 B). Similarly an ulceration on the posterior wall of the stomach which has penetrated into the pancreas may give troublesome bleeding (Fig 533 C). If one of the large vessels such as the splenic artery is perforated massive fatal hemorrhage may occur.

The symptoms produced by bleeding from a gastric ulcer depend upon the size of the vessel eroded and the amount of blood lost. The patient may notice no more than weakness and tarry stools but if a large vessel has eroded hematemesis and symptoms of shock may appear.

the clot formation in the bleeding vessel. With the advent of the blood bank quantities of blood may be stored for use as a constant intravenous drip. Sufficient blood should be available to administer at any time. The administration of blood plasma also has an important place in the treatment of these patients especially when shock is present.

After the patient has been brought into good condition medical therapy is instituted. Some physicians prefer to withhold food by mouth for a few days and then to institute a regular regimen of alkaline therapy and frequent feedings after the method of Sippy. Others following the suggestion of Meulengracht start alkaline therapy and frequent feedings immediately. Since the majority of these patients respond satisfac-

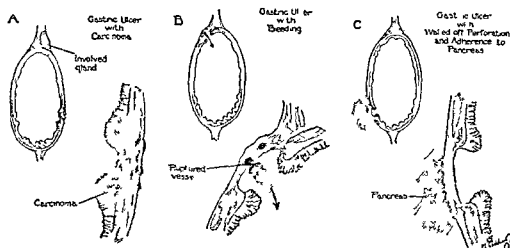


FIG. 533.—Schematic representation of complications of gastric ulcer requiring surgical treatment.

**TREATMENT**—The immediate problem in the treatment of massive hemorrhage from a gastric ulcer is to combat the acute blood loss. The pulse rate and blood pressure should be taken at frequent intervals and a complete analysis of the blood including a complete blood count and hematocrit and total plasma protein determinations should be made in order that all possible information as to the amount of blood lost may be obtained. This information serves as a guide to the time for and the amount of replacement therapy necessary. Blood transfusions should be given to maintain the systolic blood pressure at a level of 70 mm. or above but no effort should be made to elevate it to the prehemorrhage level because of the danger of disturbing

torily to medical treatment it is a difficult problem to select for early operation those individuals who might otherwise bleed to death.

No unanimity of opinion exists regarding the time and type of surgical procedure to be performed. Each instance of massive hemorrhage from gastric ulcer is an individual problem. So many patients with massive hemorrhage recover under medical treatment that the surgeon hesitates to operate upon any one suffering from acute blood loss. Moreover the surgeon may be uncertain of the actual source of the hemorrhage especially in cases in which previous roentgenologic studies have not been made. He knows from experience that the actual

bleeding point may not be found at operation. The bleeding may be from esophageal varices or gastritis instead of from an actively bleeding ulcer thereby making control of the hemorrhage impossible. However ligation of the bleeding vessel is imperative if the patient continues to show evidence of active bleeding despite repeated transfusions.

If the patient is under 50 years of age surgical treatment may be delayed because the mortality on medical treatment is less than 10 per cent. If the patient is over 50 years of age the mortality is approximately 30 per cent.<sup>1</sup> Because of this increased mortality in the older age group early surgical intervention has been recommended in this group—within forty-eight hours of the onset of massive bleeding. Regardless of the age of

Repeated massive hemorrhage is an indication for surgical intervention regardless of the age of the patient.

**2 Acute Perforation**—Acute or free perforation occurs most often on the anterior wall of the stomach (Fig. 534 A). Over 60 per cent of perforated gastric ulcers occur in patients over 40 years of age. In the majority of instances a history suggestive of ulcer may be attained but in a considerable number of instances perforation occurs in patients who have had no previous symptoms characteristic of gastric ulcer.

As a result of the escape of gastric contents into the peritoneal cavity there is a sudden severe agonizing pain in the epigastrium which soon spreads throughout the entire abdomen. In the first hour or two after per-

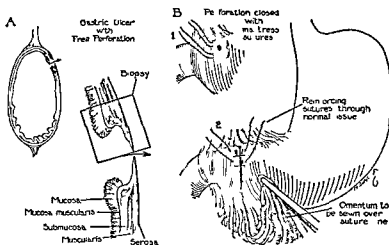


Fig. 534—A Dropsy of a perforated gastric ulcer to determine the presence or absence of malignancy. B Technique of closure of a perforated gastric ulcer.

the patient the surgeon usually prefers to delay operation for a trial of transfusion and medical treatment unless there is evidence of persistent acute loss of blood despite repeated transfusions.

In the presence of active bleeding the type of surgical procedure depends upon the condition of the patient and the technical difficulties encountered. Only the active bleeding should be stopped by the direct insertion of silk sutures in the ulcer bed. In the presence of active hemorrhage the aim of the surgeon is to save life by controlling the bleeding vessel. Further surgical procedures at this time add considerably to the operative mortality. If these procedures are necessary they should be carried out at a subsequent operation.

foration there may be signs of shock with a sudden fall in temperature. The respirations become short and grunting and there is characteristic board-like rigidity of the abdomen which is of great significance in the initial shock. Symptoms of spreading or generalized peritonitis rapidly become well established. The finding of free gas in the peritoneal cavity (pneumoperitoneum) either by roentgenograms or occasionally by physical examination definitely establishes the diagnosis. In order to determine the presence or absence of free gas in the peritoneal cavity the roentgenogram is made with the patient in an upright position so that gas if present will appear as crescents beneath the diaphragm. If the patient is too ill to be placed upright he may lie on his left side.

If free gas is present it will then appear as a bubble above the liver. Shoulder pain may be present as a result of irritation of the dome of the diaphragm referring the pain by way of the phrenic nerve. Likewise the liver dullness may be obliterated to percussion. It is usually impossible (and of academic interest) to determine from the history and physical examination whether the perforation has occurred in the duodenum or in the stomach. In either case it is imperative that the perforation be closed as soon as the patient has recovered from shock.

The differential diagnosis is at times difficult depending on the duration of the perforation and the reaction of the patient. The clinical picture may suggest acute pancreatitis, acute cholecystitis, biliary or renal colic, appendicitis with generalized peritonitis and at times coronary thrombosis. A careful history combined with the characteristic board-like rigidity of the abdomen and the sudden onset of the pain are the most important factors in making the correct diagnosis.

The patient is placed on constant gastric suction to prevent further escape of the gastric contents into the peritoneal cavity and to avoid the possibility of aspiration of the gastric contents by vomiting during and after anesthesia. The administration of blood plasma intravenously is of great importance and may be supplemented by physiologic saline solution if dehydration is present.

No further surgical procedure beyond the closure of the perforation should be attempted at this time because it would increase the mortality rate. However in view of the ever present danger of carcinoma in gastric ulcerations a very small section of the gastric wall adjacent to the perforation may be removed for biopsy (Fig 594 A). Especially should this be done if the perforation is in the prepyloric area or about the greater curvature or if the appearance of the lesion is at all suggestive of neoplasm. Even if the surgeon is certain that the perforation has occurred in a carcinoma he should merely close the perforation and leave resection for a subsequent operation after the patient has recovered. As much as possible of the infected material from the abdomen should be removed by suction.

Cultures of the peritoneal fluid are always taken. One of the sulfonamide group in powder form may be introduced directly into the peritoneal cavity to combat the peritonitis. Penicillin may also be used. Drains are usually omitted except under certain circumstances when organisms are demonstrated in direct smears of the peritoneal fluid.

Constant gastric suction is maintained for several days after operation. Nothing is given by mouth and fluids are administered intravenously. Chemotherapy may be instituted if cultures of the peritoneal fluid are positive.

The immediate postoperative complications are most frequently pulmonary such as atelectasis or bronchopneumonia. Of equal importance is the result of infection such as generalized peritonitis, subphrenic abscess or wound infection. Perforated gastric ulcers as a rule have a higher mortality rate than perforated duodenal ulcers, probably owing to the fact that the former usually occur in the older age group. The mortality increases progressively as the interval lengthens between the time of perforation and the time of closure. The prognosis is better if the perforation occurs when the stomach is empty and if the culture of the peritoneal fluid at the time of operation is negative.

Although some surgeons feel that perforation results in the cure of that particular ulcer, long range figures do not bear this out. The great majority of patients with perforated ulcers who have been followed for a long period require an additional surgical procedure because of recurrence of ulcer symptoms.

**3 Late Perforations**—If a patient is first seen forty-eight hours or longer after perforation of the gastric ulcer and if he is still in good physical condition it is usually an indication that the perforation has been walled off. Under these circumstances it is safer to avoid operation and to continue constant gastric suction and intravenous administration of fluids than it is to carry out immediate operation. Certain patients who are first seen a day or two after perforation and who are in very poor condition as a result of generalized peritonitis may survive if conservative therapy is instituted whereas they would succumb to immediate surgical

intervention. In any case large quantities of whole blood or of blood plasma should be administered.

**4 Subacute Perforation**—Subacute perforation is one through which the gastric contents leak slowly or one which is sealed off by omentum or adjacent structures before much leakage can occur. These perforations present great difficulty in differential diagnosis. The gastric contents may be directed down the right lumbar gutter producing symptoms simulating those of cholecystitis, renal disease or appendicitis. Localized abscesses about the stomach or a subphrenic abscess may occur requiring subsequent incision and drainage.

**5 Chronic Perforation**—A chronic perforation occurs most frequently on the posterior wall of the stomach and may become of surgical importance because of pain and failure of response to medical treatment (Fig. 533 C). The perforation is walled off by an adjacent structure such as the pancreas which prevents leakage of the gastric contents. Such chronic perforations are often resistant to medical treatment and have a tendency to bleed. The diagnosis and localization of this type of lesion depend largely upon physical and roentgenologic examination. Subtotal resection of the stomach may be necessary.

**6 Obstruction**—Gastric ulcers commonly produce evidence of gastric retention as a result of interference with gastric motility due to spasm, cicatricial contraction, edema or hypertrophy of the pylorus.

As a result of the obstruction the patient has distress and a feeling of fullness in the epigastrium, especially marked toward the end of the day. This distress is relieved by vomiting. When the obstruction is severe vomiting may be so frequent that the patient becomes emaciated and dehydrated with evidence of tetany due to alkalosis.

The diagnosis of complete obstruction is usually obvious. However lesser degrees of obstruction can be verified and evaluated by roentgenograms following a six hour barium meal. The diagnosis may likewise be confirmed by aspiration with the stomach tube and measurement of the amount of gastric contents withdrawn.

**Treatment**—Medical treatment should be given a trial even though the roentgeno-

gram may show 100 per cent retention of barium with a six hour meal. Often the retention due to spasm and edema may be overcome and only then may the amount actually due to cicatricial contraction be determined. Occasionally the retention is entirely controlled by medical treatment and surgical intervention is unnecessary.

Medical treatment consists of the administration of antispasmodics such as tincture of belladonna, antacid therapy and daily aspiration of the stomach. From the amount of gastric contents aspirated the physician can estimate whether the obstruction is increasing or decreasing. An effort is made to improve the general condition of the emaciated patient by the administration of a high vitamin high caloric diet consistent with his ability to retain nourishment. The alkaline therapy in complete obstruction more recently has included the administration of non absorbable neutralizing agents such as aluminum hydroxide or magnesium trisilicate to prevent disturbance in the acid base balance. If under a strict medical regimen the retention persists at 40 per cent or more following a six hour barium meal operation is indicated.

Patients with obstruction are often suffering from malnutrition, dehydration or alkalosis. In addition the stomach is so distended that it must be decompressed by constant gastric suction before any type of surgical procedure can be carried out. Otherwise the anastomosis may be distorted and disaster may follow operation. If there is evidence of dehydration or alkalosis the operation is delayed until the electrolytic balance is corrected. When obstruction is complete and the general condition of the patient is quite poor feeding by means of jejunostomy may be advisable to be followed later by a surgical attack on the gastric lesion.

While gastroenterostomy is an ideal procedure in the presence of pyloric obstruction its use in the presence of gastric ulcer must be guarded because of the danger that the lesion may be malignant.

If the symptoms of obstruction resulting from hourglass constriction cannot be overcome by medical treatment gastric resection may be necessary to correct this deformity (Fig. 532).

**Principles of Treatment —1 Medical —** Most gastric ulcers are benign and will heal without surgical intervention if adequate medical treatment is carried out. This consists of a non irritating diet and medication supplemented by an attempt to improve the general condition of the patient. Any focus of infection should be eradicated. It is important that an effort be made to improve the psychologic attitude of the patient so as to insure freedom from worry. The medication may vary but always consists of the administration of some form of antacid at frequent intervals. Belladonna or atropine is given to overcome spasm which interferes with gastric motility and in some instances it is supplemented by a sedative. Because of the danger of carcinoma the patient with gastric ulcer must be kept under rigid supervision preferably in bed in the hospital until the ulcer has healed.

**2 Surgical A Failure of Medical Treatment —**In general unless the surgeon is familiar with the quality and duration of the medical treatment he should recommend operation only for the complications of ulcer. However a small group of patients especially those with an ulcer of the posterior penetrating type continue to have pain and distress despite adequate medical treatment. For these patients resection is advisable. Occasionally because of financial status a patient may be unable to continue medical treatment for a sufficient length of time to effect a cure. In such instances surgical treatment may be considered. The surgeon should not recommend it as a means of escape to those who are unwilling to adhere to the restrictions of diet imposed by medical treatment or to those who are intemperate in their habits.

**B Suspicion of Cancer —**The primary consideration in the treatment of gastric ulcer is to rule out the possibility of carcinoma and to make certain that early eradication is undertaken if the location or progress of the lesion is at all questionable. The clinician should consider the possibility of carcinoma if the ulcer is located in the prepyloric inch or on the greater curvature of the stomach if it is larger than 3 cm. regardless of location and if it fails to show sufficient improvement after three weeks of adequate medical treatment. Even though

the patient is under forty years of age has high acid values in the gastric secretions and apparently improves clinically and roentgenographically he may harbor a malignant lesion. Therefore every patient with gastric ulcer demands constant supervision and the closest cooperation among physician roentgenologist and surgeon.

**C Choice of Operation —**There is no standardized surgical procedure for the treatment of gastric ulcer. The complication involved the general condition of the patient the possibility of carcinoma and the technical difficulties to be overcome govern the choice of procedure.

The incidence of jejunal ulceration is not nearly so great after surgical procedures for gastric ulcer as it is for duodenal ulcer. Therefore it is not so necessary to reduce markedly the volume of gastric juice secreted in order to prevent recurrent ulceration. A wedge shaped excision of the ulcer with the addition of gastroenterostomy often effects a cure. However at the time the ulcer is removed immediate examination of a frozen section should be made to rule out the presence of carcinoma.

Occasionally a posterior penetrating ulcer may be technically impossible to remove. If so the ulcer bed may be cauterized the edges of the ulcer excised and the stomach wall reapproximated.

If there is any question of carcinoma a radical resection which includes the lymph gland drainage area should be carried out if the general condition of the patient permits. Usually the duodenum is closed and the jejunum is anastomosed to the remaining portion of the stomach by any one of a variety of methods. Because of the existent relationship between gastric ulcer and carcinoma there is an increasing tendency to carry out radical resection for gastric ulcer. The mortality for resection is steadily decreasing and is now in the neighborhood of 5 per cent.

After operation the patient must be cautioned that it is just as important for him to avoid irritating foods alcohol and excess smoking as it was before operation.

**Prognosis —**Gastric ulcer has a tendency to recur over a period of years. In general the prognosis of gastric ulcer must be guarded because of the possibility of car



cinoma For that reason every patient with gastric ulcer should be followed closely for an indefinite period by his clinician and should have his progress checked fluoroscopically and roentgenographically at regular intervals Even though the immediate response to medical treatment may be good and further treatment may appear unnecessary an occasional patient returns with inoperable carcinoma of the stomach For that reason a patient with an ulceration especially in the so called danger areas if not subjected to surgical treatment should be given a guarded prognosis and should be supervised closely by a physician roentgenologist and surgeon Postoperative results for gastric ulcer over a long period are good and are much better than those for duodenal ulcer

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TUMORS OF THE STOMACH

The frequency of occurrence of various tumors of the stomach is given in Table 6 Carcinoma involves the stomach more frequently than does any other organic lesion

It usually occurs on the lesser curvature and on the posterior wall but may be situated in any portion of the stomach Involvement of the adjacent or surrounding lymph nodes is usual and the extent to which this has taken place determines more or less whether or not removal is possible MacCarty has considered that carcinoma is derived from the glandular cells of the mucosa and that it may arise in three structural situations (1) in the borders of chronic gastric ulcers (2) in adenomatous tumors such as poly

TABLE 6—CLASSIFICATION BASED ON HISTOPATHOLOGIC EXAMINATION OF 2505 GASTRIC TUMORS

Malignant tumors	
Carcinoma (adenocarcinoma medullary serous colloid squamous and ulcerative) with or without involvement of lymph nodes and including carcinomatous polyps	2316
Sarcoma (lymphosarcoma fibrosarcoma, myosarcoma angiosarcoma malignant endothelioma)	50
2366	
Benign tumors	
Polyps and papillomas	47
Myomas	13
Fibromyomas	11
Fibromas	7
Adenomas	15
Adenomyomas	8
Lymphangioma and hemangioma	4
Dermoid cyst	3
Cystadenoma and simple cyst	2
Lipoma	1
Squamous cell epithelioma	1
Total	92
2458	
Other conditions not strictly tumors	
Diverticulum	9
Hair ball	3
Phytobezoar	3
Total	15
2505	

loid (Fig 535) or cauliflower growths as parts of the pedunculated polyps and (3) possibly in regions of chronic gastritis without the presence of an ulcer or polyp The essential features of the tissue pathology of the other tumors of the stomach according to MacCarty are as follows

Sarcomas or malignant neoplasms of mesoblastic origin in the stomach are not uncommon The diffuse lymphoblastic sarcoma is the most frequent and is composed of malignant lymphoblasts the histologic

and cytologic picture being indistinguishable from those seen in Hodgkin's disease, lymphatic leukemia and lymphosarcoma. It occurs usually as a localized lesion in the stomach although it has been seen as a diffuse condition involving all the gastric coats. Lymphoblastic sarcoma also produces a diffuse thickening of the gastric wall which may be irregularly and even nodularly enlarged making the gross differential diagnosis between carcinoma and sarcoma often difficult and usually impossible without microscopic study.

Single and multiple *polyps* in the stomach are relatively rare. They occur in all the portions of the organ and may or may

not infrequently be seen in association with pyloric obstruction. It is the function of the surgical pathologist to determine which myomas, fibromyomas and fibromas also are sarcomatous.

*Angiomas, lipomas and fibromas* are relatively rare but they may originate in any part of the gastric wall. A tumor of one of these types may arise in the submucosa as a rounded tumor not involving either the mucosa or the muscularis but pushing the mucosa toward the lumen and the muscularis toward the serosa forming a visible and palpable circumscribed mass. The exact nature of these tumors is not recognized until after pathologic examination.



Fig. 53a.—Pedunculated carcinoma of the stomach.

not produce obstruction of the gastric outlet by projecting into the pylorus and even the duodenum. They are pedunculated and enomatous outgrowths of the mucosa and contain all the tissues of that portion of the gastric wall. They may be single or multiple, small or large, the largest (in our series) being 8 cm. and the smallest 6 mm. in diameter. Polyps may be either benign or malignant and the diagnosis can be determined with accuracy only on pathologic examination.

*Epitheliomas* or malignant tumors composed of squamous epithelium are extremely rare in the stomach.

*Myomas* are characterized by localized well demarcated enlargements of the muscle of the gastric wall. These must be differentiated from the diffuse muscular hyper-

trophy not infrequently seen in association with pyloric obstruction. It is the function of the surgical pathologist to determine which myomas, fibromyomas and fibromas also are sarcomatous.

*Idenomas* or tumors composed of differentiated glandular cells arranged in acinar form are relatively rare. A tumor of one of these types may be associated with, but may have no apparent relation to, carcinoma and it may project into the gastric cavity producing a polypoid mass.

Simple *cysts* forming tumors and polyps, cystic tumors lined by differential columnar epithelium and containing mucoid or clear fluid are extremely rare. Dermoid or cystic tumors lined by squamous epithelium and containing disintegrating fat and sometimes hair are rare. The largest tumor of this type encountered at the Mayo Clinic weighed 1000 Gm.

The majority of *diverticula* are found as

masses near the pylorus and are not recognized positively until after resection. They are invaginations of the mucosa and submucosa through the muscularis" and as such are not true tumors although they may often confuse the diagnosis.

Foreign bodies may often be mistaken for tumors of the stomach, and operation may be advised. Hair balls (trichobezoars) and masses of retained remnants of ingested fruits (phytobezoars) are occasionally encountered.

### CARCINOMA OF THE STOMACH

It has been estimated that 38 000 persons die annually in the United States from carcinoma of the stomach, one of the most seri-

ous in symptoms and clinical course, a benign ulcer even by responding temporarily to medical treatment.

There is great variability in the manifestations of the disease. Gastric carcinoma ulcerating or otherwise may temporarily simulate peptic ulcer, especially at the outset. Later, however, the carcinomatous nature of the lesion or the transformation of a benign into a carcinomatous ulcer may be suggested symptomatically by one of the following: (1) disappearance of intermittency of the exacerbation with substitution of a remittent or continuous clinical course, (2) irregularity, diminution or disappearance of the "pain-food-ease" sequence, (3) substitution of the usual pain or distress by a dull



Fig. 536.—Polypoid carcinoma of the posterior wall of the stomach.

ous of all malignant processes. Men are afflicted about three times as often as women. The majority of persons who have such malignant tumors are seen when they are between the ages of forty and sixty years, the average age being fifty-five years.

**Symptomatology.**—The symptoms of carcinoma of the stomach are determined partly by the site of the growth, by its extent and by the degree of motor impairment which it causes. A lesion confined to the pars media at the lesser curvature or one that lies on the anterior or posterior wall (Fig. 536) may be silent until well advanced, a tumor near either the pyloric or the cardiac orifice may cause marked obstruction before giving any other evidence of its presence, a small ulcerating, especially a crateriform lesion may

ache more or less constant and eventually aggravated rather than eased by alimentation and (4) loss of appetite and onset of nausea, both of which may ensue even in the presence of adequate gastric acidity.

Objectively, a diminution of the gastric acidity, a disturbance of motor function, the onset of anemia in the absence of gross hemorrhage and the appearance, increase or persistence of occult blood in the gastric content and feces are significant.

Epigastric distress occurs in about 90 per cent of cases when carcinoma of the stomach has been fairly well established or has become advanced. Vomiting is experienced in from 60 to 80 per cent of such cases. Gaseous eructation usually is found and in many instances becomes gradually more marked.

Loss of appetite and loss of weight frequently are complained of and may occur early in the disease. Bleeding from the stomach is evidenced by vomiting of blood or the passage of black, tarry stools, but this is much less common in carcinoma than in ulcer. In about two thirds of the cases there is a definitely demonstrable mass in the upper part of the abdomen (Fig. 537).

**Diagnosis.**—It is an accepted fact that the chief basis of successful treatment of carcinoma of the stomach is early diagnosis. Factors essential to more prompt recognition of this malignant condition are: (1) physical examination at stated intervals by a competent physician, (2) the attaching of proper significance to indigestion of an un-

examination (roentgenologic) by which the early, symptomless lesion can be detected is easily overlooked. Too often the symptoms become so bizarre or the disease so far advanced that it has passed the curable stage before it can be recognized. For these various reasons, the patient often deprives himself of the opportunity for cure by a timely operation.

The important points usually enumerated for diagnosis of carcinoma of the stomach are as follows. (1) onset, in a person at the so-called "cancer age" (from forty to sixty years), of dyspepsia, associated with anorexia, pain and vomiting which has resisted treatment for three months, (2) steady loss of weight and (3) progressive anemia

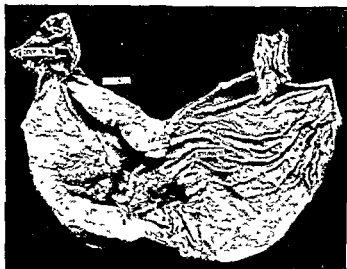


Fig 537—Scirrhous carcinoma of the antrum of the stomach

explainable or persistent nature, which may have begun insidiously or abruptly after the fourth decade of life, (3) the seeking of medical advice promptly under the circumstances, (4) employment of all available laboratory methods of diagnosis, of which roentgenology is by far the most important and is essential to the detection of carcinoma in its earliest stages or in its obscure form, and (5) closest cooperation between clinician, roentgenologist, surgeon and pathologist.

The middle-aged layman too frequently delays in seeking medical advice for digestive disturbances, and the early clinical signs of carcinoma of the stomach are often so indefinite that the necessity of the only

These represent symptoms, in most instances, of advanced carcinoma, and if the patient is to receive the benefit of surgical removal of the malignant process, the disease should be recognized earlier.

It cannot be too strongly emphasized, therefore, that if there is any persistent disturbance in gastric function, particularly if it is of recent appearance, mild or severe, and if the history reveals any irregular or atypical syndrome of ulcer or a certain departure from normal results in an analysis of the gastric content or any tendency to gastric retention or obstruction, the possibility of carcinoma always must be kept in mind, and an experienced physician and roentgenologist must be consulted. It is an

unfortunate paradox that although the disease can be identified readily in its early stages this is rarely done.

The question arises as to whether in the diagnosis of carcinoma of the stomach roentgenologic and gastroscopic methods can supersede all others. The recent development of gastroscopy has added much to the knowledge of both benign and malignant lesions of the stomach and has shown that it is possible to make visible these small lesions which are so situated that even the expert roentgenologist may not be able to detect them either roentgenographically or roentgenoscopically.

The experienced clinician will not delay until definite symptoms and signs appear but on suspicion will demand if necessary repeated roentgenoscopic examinations and if advisable gastroscopic examination. He will not be deluded into believing that a patient cannot have a carcinoma of the stomach when he is apparently in good health and when values for gastric acids are normal weight has not been lost and a tumor is not palpable.

It has been suggested that if there is doubt from its roentgenologic appearance as to whether a lesion is malignant or not the differential diagnosis can be made by observing the results of medical care if the condition is relieved it may be assumed that the lesion is benign. McVicar and others found however that this might give an erroneous impression since the patient temporarily may respond satisfactorily to medical treatment. The clinician therefore is primarily concerned with the indications for exploration and with the probabilities of the removal of the growth; the latter offers the patient his only chance for cure. The surgeon is interested to learn about the degree of extension of the growth, the possibility of its complete removal and the grade of malignancy as defined by Broders; the surgeon also wishes to know what degree of palliation may be afforded the patient if cure is not possible, which of the various procedures that have been evolved to bring about either cure or palliation is indicated in a particular case and how great will be the risk of operation.

Gastric carcinoma must always be distinguished from such intrinsic lesions as gas-

tric ulcer and benign tumor from such conditions as chronic gastritis, gastric syphilis and gastric tuberculosis and from phytobezoars especially when they are associated with large crater-like ulcers. Extrinsic lesions to be excluded are diseases of the pancreas, gallbladder and colon, some degenerative lesions of the kidneys, lungs, liver and suprarenal glands, digestive disturbances resulting from toxemia, secretory dysfunction, chronic glomerular nephritis and diffuse nephritis and pernicious anemia.

**Indications for Treatment**—It should always be kept in mind that death surely will occur within a period of months if the disease is not interrupted in its course. The purpose of treatment therefore is two fold: (1) to effect cure if possible or (2) to prolong life and assure the patient of a minimum of suffering. Non-surgical methods including radiation are purely symptomatic or palliative in effect.

Cure of carcinoma of the stomach by surgical treatment has been accomplished in a sufficient number of cases to remove any doubt that it is possible under certain circumstances. In addition to this ever present possibility surgical treatment properly applied in many of the less favorable cases will prolong life, will protect the patient against disagreeable complications and in many respects will fully justify itself.

When a diagnosis of tumor of the stomach has been made or a lesion is demonstrated which may be malignant the indications for its treatment present many important considerations. A fundamental principle is that every patient is entitled to exploration unless the disease can be proved to be incurable and unless it is perfectly obvious that a palliative procedure also would be unwise. This means that unless a definite metastasis can be demonstrated unless the fluoroscope reveals involvement of the cardia or unless both roentgenologist and clinician realize that the lesion is irreparable surgical exploration of the growth is warranted. The surgeon will base his advice on the standpoint that cure may sometimes be brought about even in cases in which on examination the disease appears too far advanced for cure.

The question of metastasis of carcinoma of the stomach is of first importance in de-

termining whether or not surgical treatment is indicated. Fortunately, early, distant metastasis occurs in situations in which it can be detected by careful examination; when it is found, any prospects of cure are dispelled, but when it is overlooked, unnecessary exploration may be made. The most common sites for signs of distant metastasis are the supraclavicular lymph nodes and the peritoneum of the rectal shelf. Positive findings by palpation or by histologic examination of a lymph node follow-

Pain of gastric carcinoma has significance in respect to operability. Although distress is a common symptom, severe pain is rare and is usually significant of extragastric involvement, from penetration or perforation by the growth. Pain, therefore, is an unfavorable sign and probably indicates that the possibilities are remote for eradication of the disease.

On the basis of what has been said in the foregoing, exploration is advised in more than half of the cases of malignancy of the



Fig 538.—Billroth I, von Haberer-Finney operation. The end of the stomach is anastomosed to the side of the duodenum.

ing biopsy, in either site, denote incurability but not always undesirability of exploration.

Careful examination of the peritoneum of Douglas' pouch should be made, for this may be the site not only of early but also of the only metastasis. Rectal examination of the patient who has carcinoma of the stomach never should be omitted.

The more common adjacent sites of metastasis are the liver and the umbilicus, and when they are demonstrable clinically, operation is contraindicated, regardless of other circumstances.

stomach, and when this is carried out, it is found that the growth can be removed in about 45 per cent of the cases, so explored.

The indications for operation include selection of the optimal time. The patient should be in the best condition possible, and for him to be put in this condition frequently requires hospitalization, so that the effects of obstruction can be overcome, dehydration can be counter-balanced, the stomach can be cleansed and the nutritional state and anemia can be improved as much as is reasonably possible. Correction of the effects of

the obstruction will reduce congestion in the gastric walls and often will improve the condition of the tissues so that more satisfactory and safer suture is possible.

**Surgical Treatment**—Once it has been decided that exploration at least, is indicated examination of the growth itself is of utmost importance. The extent of extragastric involvement should be determined and unless it is clearly apparent that the disease

filtrating growth may be clearly inoperable whereas a similar growth in a case in which the patient is asthenic and the stomach is prolapsed may be operable. For an extremely large ulcerating or colloid carcinoma total gastrectomy or nearly total gastrectomy is justifiable if the stomach can be mobilized whereas these operations would not be reasonable if the stomach were small and firmly fixed.

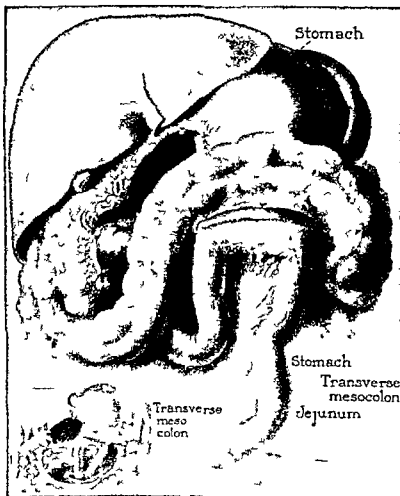


Fig. 539.—Posterior anastomosis. The end of the stomach is anastomosed to the side of the jejunum following a partial gastrectomy for carcinoma of the stomach.

is not eradicable the lesser peritoneal cavity should be widely opened through the gastrocolic omentum to allow inspection of the extent and the character of any posterior perforation or attachments.

Decision as to whether resection is justifiable or not depends also to a considerable extent on the type of stomach in which the growth has occurred. In those cases in which the stomach is small and high lying an in-

If it is obvious that the lesion is too wide spread to be removed the distressing situation which arises from an erroneous diagnosis should always be guarded against by removal of tissue for microscopic examination.

If resection seems to be justifiable there are many methods by which it may be accomplished and partial gastrectomy has been developed to a point at which the dan-

gers which were commonly fatal in the past have been largely eliminated. As far as general principles are concerned the growth should be removed as widely as possible, gastrointestinal continuity should be re-established without undue tension and the mechanical function should be perfect.

The methods conform to one or the other of two types: direct anastomosis between the end of the stomach and the duodenum (Fig. 538) or closure of the duodenal stump and union of the remaining portion of the stomach with the first loop of the jejunum

the duodenojejunal angle by a small enteroanastomosis; this prevents retrograde distention of the duodenum and obviates the possibility of danger from that source.

The advances made in recent years are illustrated in the increasing frequency with which total gastrectomy is performed, since this operation is now being done with considerably less risk than formerly (Fig. 541). The transthoracic approach to high lying malignant lesions which encroach on the esophagus has distinct advantages. The percentage of cures following the operation un-

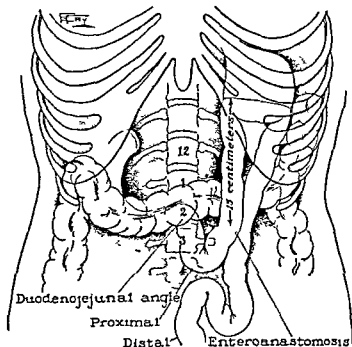


Fig. 540—Position occupied by the stomach and jejunum after extensive gastric resection and restoration of the continuity by an anterior end-to-side anastomosis with enteroanastomosis.

Anastomosis between the end of the stomach (Fig. 539) and the side of the jejunum has attained the greatest favor largely because it consumes less time than the Billroth II procedure. The gastrojejunal anastomosis can be made either behind the colon or in front of it (Fig. 540). The posterior method can be used in many cases without difficulty, but when after extensive resection only a small segment of stomach is left it is simpler, safer and less likely to give rise to complications to bring a long loop of jejunum up in front of the colon and to attach the loop to the end of the stomach. When this operation is completed the two loops of jejunum should be united opposite

doubtedly will be low chiefly for the reason that the operation usually is indicated only when the disease is advanced. This fact together with the relatively high risk of the operation would indicate that only in well selected cases is the operation advisable.

Gastroenterostomy occasionally is useful when it is performed preliminary to resection. Apparently, however, the indications for its use in the treatment of carcinoma are becoming less and less. In the first place if gastroenterostomy can be satisfactorily performed the disease cannot have extended very far toward the earlier in which case at least exclusion of the growth probably could be effected or even palliative resection



could be performed. Experience has shown that when the disease is very extensive and gastroenterostomy is attempted the surgeon may be forced to place the stomal in an unsatisfactory situation so that it fails in its purpose of providing adequate drainage; moreover the risk of operation is considerable since immediate improvement is not realized to as nearly a complete degree as when obstruction is satisfactorily relieved. A further objection to gastroenterostomy alone is that even when it fulfills its purpose of relieving obstruction if the disease extends the gastroenteric stomal is prone to become involved in the malignant process and obstruction recurs.

course to gastric lavage when indicated may be effective in maintaining a good state of nutrition and the physical comfort of the patient for a considerable period.

If obstruction is marked frequent aspiration of the gastric content will prove to be of distinct benefit in improving the general condition of the patient and will assist materially in the technical surgical procedure by presenting for the surgeon's consideration a stomach that has been cleansed thoroughly of all retained material. The diet should be liquid or semifluid and not too much should be given at one time.

The value of radiation for irremovable malignant processes in the stomach, as well

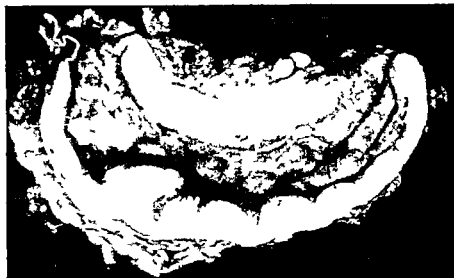


Fig. 511.—Serious carcinoma involving the entire stomach for which total gastrectomy was performed.

**Palliative Treatment**—Increasing experience confirms the early observation made by W. J. Mayo that great palliation frequently could be obtained in certain types of gastric carcinoma. The various palliative measures for carcinoma of the stomach include both medical and surgical treatment. The medical treatment has not been given sufficient emphasis by members of the medical profession because the merit of any method usually has been judged solely on the basis of permanency of cure. Due consideration has not been given the effect of such methods in the control of distressing symptoms.

Intelligent choice and use of a suitable dietary regimen, sedatives, opiates, tonics, and digestants, rectal alimentation and re-

as its merit as a postoperative measure has not been established because of the indefinite results which have followed such treatments. Surgical methods of palliation include gastric resection, exclusion of the growth, gastroenterostomy and jejunostomy.

**Results of Treatment**—The mortality following operations for carcinoma of the stomach can be markedly lowered by scrupulous attention to preoperative treatment. If the physician cooperates with the surgeon in maintaining good care after the operation the risk is reduced to a minimum.

If operation for gastric carcinoma is carried out along the general lines that have been outlined the rate of operability is approximately 45 per cent. The possibilities of cure in cases of carcinoma of the stomach

are shown by the fact that of several series of consecutive cases in which resection was carried out an average of 90 per cent of the patients are alive and apparently well three years after operation regardless of the extent of the disease at the time of resection. If those cases are selected in which the disease is still confined to the stomach that is in which there is no involvement of lymphatic structures 49 per cent of the patients are alive and apparently well three years after resection. A low mortality rate for operations is dependent on a number of factors the chief of which are (1) good judgment in deciding on the possibility of cure or worth while palliation (2) adequate preparation of the patient for operation (3) meticulous care and skill in carrying out all the details of the operation and (4) adequate postoperative care. If these essentials can be met hospital mortality rates for gastric resection for carcinoma of the stomach of less than 10 per cent are being reported.

#### BENIGN TUMORS

The actual proportion of benign tumors to malignant tumors of the stomach is 1:200 and benign tumors form 1.3 per cent of all gastric growths. They present a wide variety of histologic types adenomatous and fibro adenomatous polyps fibromas myomas hemangiomas dermoid cysts papillomas polypoid masses neurogenic tumors leiomyomas and also lipomas.

Benign tumors in themselves are symptomless unless they are complicated by bleeding or ulceration or unless because of their size and extent they cause intermittent obstruction of the pylorus or interference with gastric motility and secretion. In 20 per cent of cases symptoms of pyloric obstruction are present. Hemorrhage from ulceration of the tumors is a more common complication and may be severe. The most frequent and most important sign of benign tumor of the stomach is anemia. This is usually of the secondary type but in cases of long standing the anemia may progress to a point suggestive of anemia of the primary type. In all of the cases of this type seen by the writer the blood picture returned to normal after removal of the polyps. Another interesting observation in all cases of polyp uncomplicated by other gastric lesions is the

absence of free hydrochloric acid from the gastric content. This tends to obscure still further the differential diagnosis of pernicious anemia gastric carcinoma and benign tumors. In some cases the only physical finding suggestive of benign tumor was that the tumor was large enough to be palpable. Usually however benign tumors are relatively symptomless and when small not eroded not too near the pylorus and not associated with other lesions are rarely diagnosed clinically except by roentgenologic examination.

Roentgenologically the condition is more suggestive than diagnostic and with the ex-

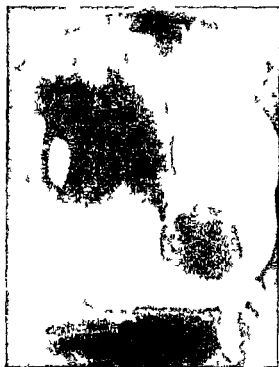


Fig 540—Benign tumor of the stomach

ception of gastric polypoidosis with characteristic mottling of the shadow to identify the type of tumor is not possible (Fig 540). Moore stated that in general a benign tumor produces a circumscribed and punched out filling defect usually on the gastric walls leaving the curvatures regular and plant. Although the rugae are obliterated from the immediate area of the tumor just as is true in the presence of inflammatory and malignant lesions the rugae which surround the benign tumor are more nearly normal in arrangement and distribution. Little disturbance in peristalsis is noted and there is no niche, incisura or other evidence of spasm.

As in carcinoma and sarcoma of the stomach, treatment for benign tumors is by surgical removal. Most benign tumors, partic-

duodenum, and probably a diagnosis of tumor of the duodenum is made. This is an essential point in determining the prognosis

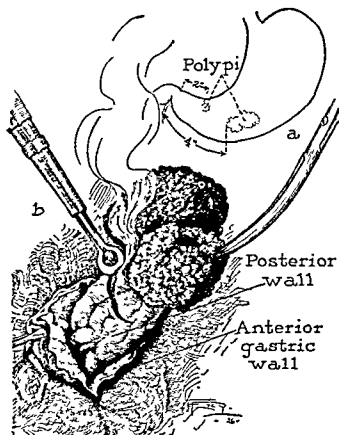


Fig. 543.—Cautery knife incision for multiple gastric papillomas



Fig. 544.—Sarcoma of the stomach

ularly the polyps, can be removed by amputation at the pedicle, accomplished by cauterization (Fig. 543). Occasionally, a pedunculated polyp will become invaginated into the

and is involved in the question as to whether or not the tumor may be potentially malignant, as may be the case if the growth originates in the stomach.

MISCELLANEOUS

Surgical intervention rarely is indicated for diverticula. Simple gastrotomy for removal of a bezoar, or hair ball usually is followed by complete relief.

Sarcoma of the stomach (Fig 544) is found rarely and is definitely diagnosed only on operation and histopathologic examination. Operation usually is advised because of a diagnosis of carcinoma. The primary purpose of treatment of sarcoma of the stomach is removal of the growth. Various procedures have been carried out in such cases. Of a series of 53 cases in which exploration was made in 15 the growth was inoperable; in 27 the Billroth II type of resection was performed; in 6 sleeve resection was carried out; in 3 the tumor was excised; and in 2 palliative gastroenterostomy was performed. The methods of resection are essentially the same as those employed for resection of carcinoma. In cases of sarcoma, however, there are more frequent indications for restoring gastrointestinal continuity by antecolic end to side enterostomies. More extensive resection can be accomplished in cases of sarcoma than in cases of carcinoma because of the sharper demarcation of the growth in sarcoma.

Irradiation by roentgen rays only was used after operation for sarcoma of the stomach in 14 cases. The sarcomas of the stomach which are most favorable for treatment by roentgen rays are lymphosarcomas, and if they could be diagnosed sufficiently early they might be cured by irradiation alone. The basis for the effectiveness of this treatment is that the lymphocytes are more sensitive to the rays than are any other cells of the body.

The mortality of resection for sarcoma will parallel that of carcinoma. The prospects of cure appear to be greater if radiation is employed in addition to surgical removal.

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SYPHILIS OF THE STOMACH

**Definition.**—Syphilis of the stomach is a tertiary lesion characterized anatomically by a broad plaque-like thickening of the gastric wall with superficial ulceration of the mucosa. The symptoms are generally referable to the obstructive and contractural lesions which frequently result from cicatricial changes of the specific granulation tissue.

**Etiological Considerations.**—The disease occurs in hereditary as well as in acquired cases. The factors that influence the localization of the *Spirochaeta pallida* in the stomach are not known. Although quite uncommon, gastric syphilis is by no means as rare as formerly supposed. Its comparative incidence is probably 1 per cent of significant organic lesions of the stomach. The average interval between the appearance of the primary lesion and the onset of gastric symptoms is about ten years. The third and fourth decades are predilected. The affection is twice as common in the male as in the female.

**Pathology.**—Many different types of lesions have been described in connection with gastric syphilis. The only lesion which the writer has encountered or seen actually depicted is a broad rather flat thickening of the gastric wall which tends to be associated with superficial ulceration. A true gummy tumor exhibiting gross caseation such as occurs in the liver for instance has not been observed in the stomach. Isolated round calloused ulcers which penetrate deeply and are frequently reported as syphilitic are

almost invariably peptic ulcers in luetic patients

The thickening of the gastric wall is in the nature of a plaque like proliferate or infiltrate which is of variable length and width. Frequently the thickening occupies the entire circumference of the stomach in which event stenosis results. Only rarely is the entire stomach involved producing the leather bottle type of contracture. The prepyloric and mid portions are sites of predilection for encircling lesions. At times there are two or more thickened areas separated from one another by relatively healthy gastric wall. The proliferated tissue involves chiefly the submucosa which occupies three fourths or more of the thickness of the gastric wall. The proliferate forms a flat elevation the central portions of which tend to undergo ulceration. A single large denudation may involve most of the elevation or the defects may be multiple and separated by islands of intact mucosa. The ulcers are of irregular shape with serpiginous outlines and are quite superficial. Since the erosion occurs at the summit of the proliferate the floor of the ulcer is well above the surface of the normal mucosa in contrast to the relationships which obtain in peptic ulcer.

Microscopically the thickening in the active stage consists of specific granulation tissue including particularly a panvasculitis infiltrates of round and plasma cells and not infrequently miliumy gummas. In the advanced state cicatricial tissue is chiefly in evidence. The involvement is primarily and predominantly submucous with extension to the adjacent layers. The mucosa becomes the seat of a non specific atrophic gastritis. The stomach is generally free from perigastric adhesions the latter when present being the result of secondary infection. The neighboring lymph glands are only moderately enlarged and succulent. The most frequent associated syphilitic lesion observed by the surgeon is a gummatous hepatitis or hepatic lobatum. Only rarely are specific lesions encountered in the intestine or spleen.

**Symptomatology**—The gastric manifestations are referable generally to increasing motor impairment. Discomfort gradually develops shortly or immediately after meals. Vomiting which appears relatively early in the illness usually affords relief and ab-

stinence from solid and coarse foods ameliorates the suffering. At times the rhythm of the postprandial pain bears a resemblance to that of ulcer but is not nearly so constant. Anorexia is generally absent in fact the appetite is good but starvation may result early because of sitophobia.

The discomfort and vomiting tend to progress slowly. The patient reduces the diet voluntarily until all but liquids are banished. In the advanced stages the symptoms are due to a reduction in the capacity of the stomach. By that time there is considerable loss of weight but no significant degree of anemia. Profuse hemorrhage or perforation is quite rare. In cases of prolonged starvation deficiency diseases may develop.

Emaciation is the only outstanding physical sign. Usually no mass is palpable. Gastric analysis demonstrates the presence of achlorhydria and less frequently of hypoacidity. Occult blood although frequently present in the stools is not uncommonly absent. The roentgenogram discloses a circumscribed and occasionally a diffuse smooth contractual lesion generally symmetrical with stiffening of the involved portions of the gastric wall. The Wassermann test of the blood is only exceptionally negative. Clinical evidences of lues other than those pertaining to the stomach may be present.

The advent of gastroscopy has aided in the diagnosis of syphilis of the stomach. Moutier has given a complete gastroscopic description of gastric syphilis. He describes tumor formations, gummas, multiple ulceration and scarring, hemorrhagic gastritis and atresia (initis plastica). Atrophic hypertrophic and mixed gastritic changes on the basis of syphilis have been recorded by others.

**Diagnosis**—The presence of syphilis of the stomach is to be considered whenever an atypical case of gastric disorder is presented. The combination of symptoms of a benign lesion from the standpoint of duration, roentgenographic evidence and acidity corresponding to those of malignant disease serves to suggest the presence of gastric lues. A positive Wassermann reaction in a patient with organic disease of the stomach should likewise lead to the suspicion of a specific etiology. The chief difficulty lies in distin-

guishing gastric lues from carcinoma. In favor of the former are the age of the patient, the duration of the illness, the lack of significant anemia in spite of emaciation, a smooth contractural deformity in the roentgenogram without the intrusion into the lumen of a growth, and the serological and clinical evidence of syphilis. A disproportion between the extensive involvement of the stomach roentgenologically and the comparatively good physical condition of the patient favors a luetic etiology. Of value also in the diagnosis is the therapeutic test provided an advanced obstructive lesion does not exist. The results of antiluetic treatment can be followed roentgenologically as well as clinically.

Often the differential diagnosis must be made at operation. Here the surgeon will generally be impressed by the fact that he is dealing with a lesion which is unlike any gastric carcinoma or peptic ulcer he has encountered. This alone should suggest the possibility of lues. The granulomatous proliferate, unlike that of carcinoma, is soft and succulent and presents the characteristics described under pathology. A biopsy specimen removed at operation is generally reported as chronic inflammatory tissue and serves to rule out carcinoma. The only gastric affection other than carcinoma which requires serious attention in the differential diagnosis of syphilis of the stomach is a prepyloric ulcer with obstruction. Corrosive poisoning, extensive perigastritis, subacute or chronic phlegmonous gastritis, lymphogranuloma (Hodgkin's) and lymphosarcoma occasionally enter into consideration.

**Treatment.**—A knowledge of syphilis of the stomach is of practical import because the disease lends itself admirably to treatment. Specific therapy is given credit for numerous complete cures, chiefly by roentgenologists and internists. There is no question but that medical treatment should be attempted wherever mechanical relief of an obstruction is not urgent. Many cases undoubtedly yield to medical management. However, since the proliferation tends to heal by cicatrization, cure of the lesion frequently results in strictures which sooner or later necessitate operative intervention. In cases of high grade motor insufficiency, a therapeutic test is not warranted as the ob-

struction generally fails to recede and the gravity of a subsequent operation is increased as a result of the delay. The aim should be to perform the simplest type of anastomotic operation. Gastroenterostomy suffices in a large percentage of cases. Care should be exercised in choosing healthy gastric wall for the site of the stoma. When the lesion is extensive, subtotal gastrectomy is required. Total gastrectomy is rarely indicated. Antiluetic treatment is to be administered energetically in the preoperative as well as postoperative stages. Following extensive resections, an antineuritic regimen is instituted.

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#### NON ULCERATIVE LESIONS OF THE DUODENUM

This section deals with pathologic entities and lesions of the duodenum other than ulcer. Surgical treatment is required in some cases; in others it is decidedly contraindicated. The differential diagnosis is often dif-

ficult and confusing The combined judgment of internist, roentgenologist and surgeon, working as a team and having a combined mature experience, is essential in dealing with these patients if the correct therapy is to be given In many cases the help and cooperation of the psychiatrist is needed in the study and treatment

In preparing this section the writer, who for many years has been interested in duodenal pathology, has utilized the very abundant material of the Vanderbilt Clinic and the Presbyterian Hospital of Columbia University This clinic is the out patient department of six affiliated institutions All patients going to the wards of these hospitals are studied admitted discharged and followed in the Vanderbilt Clinic, and on admission as a patient, the history, physical examination and laboratory findings become

TABLE 7—*LESIONS OF THE DUODENUM OTHER THAN ULCER FROM VANDERBILT CLINIC—PRESBYTERIAN HOSPITAL SERIES*

Congenital atresia or stenosis	5
Anomalies of the duodenum	62
Diverticulum	57
Duodenal stasis without obstruction	36
Duodenal stasis with obstruction	36
Duodenal fistula internal	10
Duodenal fistula external	8
Duodenitis	6
Foreign body in duodenum	4
Primary tumors of the duodenum	13
Total	257

a unit record, to go with him to whichever of the affiliated institutions he may be admitted subsequently In this way continuous and continuing records of inestimable value have accumulated far superior to the old fashioned bound volumes containing isolated records of each admission of a patient in each of several institutions for they contain not only the data of each admission, but also follow up notes of the interval between admissions

The classification of the entities and lesions of the duodenum, with the number of cases under each heading, is given in Table 7

Before dealing with the separate entities it is important to discuss certain fundamental factors related to duodenal lesions Ivy has discussed and summarized these and the following is based on his article on the physiology of the duodenum<sup>1</sup>

Functions of the Duodenum. (1) motility, (2) secretion and (3) absorption

1 *Motility*—(a) *Rhythmic segmentation*—to mix duodenal bile and pancreatic juice with incoming chyme (b) peristalsis initiated by the ejection of stomach contents into the duodenum There is considerable debate as to whether the peristaltic wave from the stomach passes in continuity over the pylorus on to the duodenum It has been shown by Ivy that during hunger motility of the stomach, the duodenum shows contractions synchronous with those in the stomach with the exception that frequently the duodenal contractions lag behind those in the stomach He believes that hunger contractions or their effect pass from the stomach to the duodenum

There are two points in the duodenum where there is a tendency to retention—the bulb and the lowest point of the duodenum i. e. the junction of the second and third portions Any pressure or angulation at these points as by a hepatoduodenocolic band over the bulb or angulation of the prearcotic portion by the overlying superior mesenteric vessels will accentuate this tendency

The question as to how much pressure is necessary to overcome the propulsive force of duodenal contraction or peristalsis has been studied by the Dragstedts<sup>2</sup> They showed that a circular extrinsic pressure by a light rubber band equivalent to 6 inches of water is sufficient to cause lethal acute duodenal obstruction Considerably more pressure is required to overcome the normal propulsive force of peristalsis in the jejunum ileum and colon An extrinsic pressure of less than 6 inches of water is sufficient to produce partial obstruction with its associated hyperperistalsis, dilatation nausea and vomiting

Reversed peristalsis has been noted fluoroscopically under normal and abnormal conditions It occurs normally in some persons at the end of a meal when strong acid chyme is being ejected into the duodenum Ivy<sup>1</sup> has shown that in a dog in good health after recovering from the establishment of a Thury duodenal fistula bile is regurgitated into the stomach when acid or a mildly irritating substance is injected into the fistula This indicates that reversed peristalsis can be produced reflexly through the celiac ganglion

*The Effect of Duodenal Stimulation on the Motor Activity of Other Parts of the Gastrointestinal Tract*—Brunemeier and Carlson<sup>3</sup> confirmed by Ivy have shown that stimulation of the duodenum inhibits the motility of the empty stomach

*Vomiting*—Luckhardt Phillips and Carlson<sup>4</sup> corroborated by subsequent observers showed that vomiting is more readily produced by duodenal than by gastric irritation Ivy<sup>1</sup> experimenting with a duodenal balloon was able to inhibit the vomiting impulse caused by pharyngeal and gastric irritation but could not control the impulse to vomit when the duodenum was irritated because of the more sudden and violent impulse

*Colon*—Ivy and McIlvaine<sup>5</sup> observed that in dogs with a Thury fistula the colon was responsive to duodenal stimulation When acid or other stimulants were first applied to the Thury fistula of the duodenum either defecation or vomiting and sometimes both resulted

*Hicough*—Ivy<sup>1</sup> has observed hicough to occur repeatedly on sudden distention of a duodenal Thury fistula in dogs.

*Bile Tract*—It has been demonstrated since Meltzer's early experiments in 1917 and corroborated subsequently by such observers as Lyons, Rous and Graham, that stimulation of the duodenal mucosa plays a fundamental role in the flow of bile from the gall bladder and ducts.

*Secretion*—By establishing a Thury fistula of the duodenum the rate of secretion its character and content and response to various stimuli can be studied. Ivy<sup>2</sup> has summarized these phases in his discussion of the physiology of the duodenum. He finds no evidence that the duodenum excretes any specific substance or has any role as an excretory organ.

*Absorption*—It is known from experimental study that the duodenum rapidly absorbs water, glucose, alcohol and crystalline. Probably little absorption of food occurs in normal digestion because of the rapid passage of gastric contents through the duodenum.

In acute duodenal obstruction experimentally produced it has been shown that toxic substances are absorbed through the duodenal mucosa. Whether absorption of poisonous products takes place in chronic duodenal dilatation or obstruction is questionable. The writer has seen cases of long-standing mechanical duodenal obstruction in which there was no evidence of absorption of toxic substances as long as the obstruction was not complete.

*Innervation*—1. *Efferent*—Data regarding the exact efferent innervation of the duodenum are not satisfactory. Ivy<sup>3</sup> teaches that the vagi and the splanchnic nerves probably carry both motor and inhibitory fibers to the duodenum, the vagi being predominantly motor and the splanchnics predominantly inhibitory.

2. *Afferent*—The exact afferent nerve paths from the duodenum have not been demonstrated but whatever the afferent nerve routes there is no question now regarding the definite subjective sensations produced by duodenal stimulation or irritation.

Ivy<sup>4</sup> and his pupils experimenting on themselves by means of a balloon placed in the duodenum have described their symptoms accurately. Nausea is the most frequent symptom and can be distinguished from the pharyngeal and gastric nausea by a sick and violent impulse to vomit. Pain is next in frequency. Either distention or spasm of the duodenum causes it. On distending the balloon when it was in the third portion Ivy referred the pain to the midline from 3 to 5 cm above the umbilicus. When the balloon was withdrawn pain was felt beneath the liver on the right side. On two occasions a sore spot persisted over the clavicle at the junction of the outer and middle thirds. Other symptoms less constantly observed were uneasiness, faintness, dizziness, chilliness and dragging and aching sensations. Pallor was a frequent physical sign. It was observed that after removal of the balloon no "after image"—persistent sensation of the balloon or distention in the duodenum—remained. Frontal headache was also observed as an accompanying and persistent symptom.

*Inhibitory Factors to Motility*—The Dragstedts<sup>5</sup> have shown that the propulsive force of duodenal peristalsis is inhibited by much less force than that

in other parts of the intestinal tract. This may explain how the inhibitory impulses coming through the splanchnic nerves and controlled by psychogenic factors may from time to time result in a dilatation and duodenal delay in the cases in which under ordinary conditions slight obstruction or angulation produces no disturbance in the propulsive efficiency of the duodenum.

With these physiologic and experimental points in mind, it must be emphasized that in the large group of patients showing duodenal dilatation and duodenal delay, whether they be in the group with definite obstruction demonstrable by barium study, or on the operating table, or at autopsy, or in the group with no demonstrable obstruction, or in the group of patients with duodenal diverticulum with barium retention or evidences of inflammation the factors of duodenal irritation and abnormal duodenal stimulation give rise to symptoms and signs analogous to those produced experimentally in animals or man. These common symptoms of nausea and vomiting, upper abdominal pain, distress, and distention, dizziness and headache, and vasomotor disturbances, as shown by pallor and low blood pressure, are seen in so many lesions of the upper gastrointestinal tract and bile passages and pancreas, both organic and functional that great confusion occurs in their diagnosis and therapy. This accounts for the fact that many patients with surgically remediable organic lesions have been treated for years for so called "nervous indigestion", and on the other hand in many of the patients with no organic lesions, operation is carried out, often with unnecessary and ineffective short circuiting procedures, resulting in intensified symptoms and a worse neurosis than before operation. The two most common mistakes in dealing with these patients are (1) failure by the competent experienced internist, surgeon and roentgenologist—working as a team—to study the duodenum carefully with barium fluoroscopy in order to determine the presence or absence of organic pathology and (2) in the patients in whom no obstruction or other organic lesion is found to discover and deal adequately with the underlying cause of the neurosis whether it is fear, anxiety or an associated debilitating factor in some other part of the organism. Many of the patients



in this group have deep-seated often subconscious psychogenic etiologic factors that require the skill, patience and time of an experienced psychiatrist for discovery and correction. Failure to recognize that these psychogenic factors play a dominant role in the cases of chronic duodenal stasis or duodenal dilatation is most noticeable in practically all of the studies thus far published. The failure in therapy, surgical and medical, in these cases can be largely explained by the failure to recognize and deal with the psychogenic cause so frequently present.

The writer is quite certain after studying the follow-up notes in the large series of case reports available at the Vanderbilt Clinic and Presbyterian Hospital—many of them covering a period of ten years or more—that the results of therapy hitherto published are inaccurate. If followed for a period of years the great majority of the patients, especially those without organic obstruction, show recurrent symptoms whatever therapy is used. This is especially true if the causes of fear, anxiety or worry are not removed.

#### FUNCTIONAL AFFECTIONS OF THE DUODENUM

**Etiology.**—In these patients an anxiety neurosis is practically always the etiologic factor.

**Symptomatology.**—The symptoms are those referred to in the preceding paragraphs. Nausea and vomiting, upper abdominal pain, distress, distention, dizziness, headache and vasomotor disturbances are commonly present.

**Diagnosis.**—The diagnosis is based on finding the aforementioned symptoms in the absence of demonstrable obstruction.

**Treatment.**—The patient who does not have a demonstrable organic obstruction should be treated conservatively. For surgical treatment in the majority of these cases merely adds to the psychogenic factor. The method of therapy now in use at the Presbyterian Hospital, which has tided over the attacks, was devised by Dr. Armistead Crump and is used by him with excellent results in many of the cases. It is as follows:

1 Lavage at bedtime allowing a twelve hour rest of the stomach without any food.

2 Ulcer type of diet with pureed food.

3 Feedings every two hours followed one hour later by the administration of alkalis.

4 Flexion exercises after the first week or so to increase the intra-abdominal tension and aid the weak muscle tone of both stomach and duodenum.

5 Oil retention enemata for patients in whom constipation is associated with pressure on the duodenum or the colon.

The author wishes to stress the absolute necessity of discovering and properly treating the underlying factor of anxiety in these cases. Unless this is done the patients will remain recurrent invalids and a burden to themselves and their families. This requires the training and time—in some cases weeks—of a psychiatrist or physician interested in the psychonalysis and psychotherapy of these patients. The majority of the anxiety factors are not Freudian in character and for this reason may not interest some psychonalysts. In many of our cases the social service worker was the one to discover the underlying anxiety factor.

It is interesting but pathetic to note the utter lack of appreciation of this phase of therapy on the part of some surgeons who operate on and some gastroenterologists who lavage these patients with the result that there are recurrent symptoms and the patients become more neurotic.

#### CONGENITAL DEFECTS OF THE DUODENUM

1 *Congenital atresia* or congenital stenosis of the duodenum is a lesion found in the early hours or days after birth and is usually an autopsy finding. It is fortunately rare and it is irremediable unless the stricture is limited to a narrow area in the duodenum. Donovan<sup>1</sup> has operated successfully on 4 infants with stenosis of the duodenum at the Babies Hospital, New York.

2 *Duodenum mobile and duodenum versum* consist of variations from the normal in the duodenal attachments and in the direction and length of one or more of the curves of the four divisions or portions of the duodenum. They represent a group of cases that are rarely recognized by internist, roentgenologist or surgeon to judge from the meager literature on the subject.

**Etiology.**—These anomalies are the re-

sult of deviations from the normal rotation of the duodenum and fusion of the mesoduodenum to the posterior abdominal wall in the first seven weeks of fetal life.

**Pathology**—Depending on the amount of persisting mesoduodenum and the deviation from normal curvatures varying amounts of angulation and obstruction result. In some cases the entire duodenum may be greatly dilated if the angulation is an obstructive one while others may show no pathology other than the anomaly. The 62 cases studied by the author may be divided as follows:

Two cases associated with non rotation of the gut and persistence of the duodenal

persistence of the mesoduodenum (Fig. 545 d) 1 case with deviation of the fourth portion to the right instead of to the left (Fig. 545 e, and 549), 29 cases were unclassified and consisted largely of abnormally long second portions or second portions with abnormal curvatures (Fig. 545 f).

**Symptomatology**—There may be no symptoms but when they are present they consist of periodic attacks of upper abdominal pain distress distention or uneasiness associated with nausea and vomiting of large amounts of bile stained fluid if the obstruction is distal to the papilla of Vater. Bloating and belching are usually present.

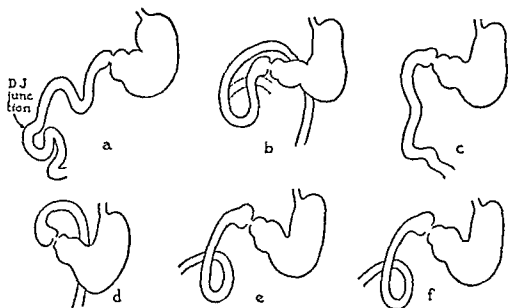


Fig. 545.—Types of congenital defects of the duodenum. *a* Associated with non-rotation of the gut and persistence of the duodenal mesentery. *b* curve to the right of the third portion. *c* variation in length and deviation from the normal curvature of the third and fourth portions. *d* curvature of the second portion upward and to the left. *e* deviation of the fourth portion to the right instead of to the left. *f* abnormally long second portion with abnormal curvature.

mesentery (Figs 545 *a* and 546), 17 cases (Figs 545 *b* and 547) all showing a curve to the right of the third portion (in some instances the third and fourth portions rose above the bulb; in others they crossed behind or in front of the second portion below the bulb; there was a persistent mesoduodenum in some cases none in others) 7 cases with varying length and deviation from normal curvature of the third and fourth portions and a variable amount of persistence of the mesoduodenum (Fig. 545 *c*), 6 cases with curvature of the second portion upward and to the left and a variable

constipation is present in the majority of the patients and they are chronic dyspeptics and cathartic users.

**Physical Signs**—There may be no physical signs. In some a sense of fullness in the upper right quadrant and to the left of the umbilicus with a splashing sound on palpation can be elicited when the duodenum is dilated. There is usually diffuse upper abdominal tenderness. There is frequently an associated visceropexiosis.

**Diagnosis**—The one diagnostic measure and a *sine qua non* is the barium meal fluoroscope and roentgen films. This study must

be made by an experienced roentgenologist, with the patient in several positions, and must be thorough and, if necessary, repeated several times. X-ray studies will differenti-



Fig 516—Congenital defect of the duodenum associated with non rotation of the gut.

ate these lesions from gastric and duodenal ulcer and diseases of the gallbladder, the two conditions most frequently confused with duodenal dilatation.

obstruction. If there is demonstrable obstruction, especially in the terminal or fourth portion, a duodenojejunostomy is indicated. If the duodenum is found to be freely movable, it should be fixed so as to approximate its normal curvatures.

**Prognosis.**—There is the same tendency in these cases of congenital defects with dilatation to recurrent attacks whether under medical or surgical treatment. If an organic obstruction has been relieved by operation, the result as a rule is good. The results obtained in the Vanderbilt Clinic—Presbyterian Hospital series are shown in Table 8

### DIVERTICULUM OF THE DUODENUM

**Definition.**—A pouch or sac-like eversion of a part of the duodenal wall

**Etiology.**—Diverticula may be congenital or acquired. They probably begin as a congenital weakness and increase in length and diameter with continued or increased internal pressure.

**Frequency.**—It is extremely difficult to give accurate figures, inasmuch as those quoted vary with the interest of the roentgenologist in the subject and the character of the clinic in which the cases have been studied.



Fig 517



Fig 518

Fig 517—Congenital defect of the duodenum with the curve to the right of the third portion

Fig 518—Congenital defect of the duodenum with a deviation of the fourth portion to the right instead of to the left.

**Treatment.**—Surgical treatment should not be advised unless conservative measures, as outlined by Crump, have completely failed after prolonged trial or unless repeated barium studies definitely show an organic

**Pathology.**—In the majority of cases the circular and longitudinal coats of the duodenum are missing, and the mucosa and muscularis mucosae make up the wall of the diverticulum. Peritoneum is absent except in

those diverticula occurring in the anterior aspect of the first portion.

The majority of diverticula are found in the second, or descending portion and along the pancreatic or mesial aspect. They vary in size from one to several centimeters in length. If the neck is narrow and the diverticulum empties with difficulty, stasis of food results and inflammatory reactions of varying

periumbilical which is made worse rather than relieved by eating and in this way differs from ulcer pain. The diverticula that empty with difficulty either because of the dependent position or narrow neck usually cause more constant and severe symptoms.

Physical examination may or may not show a constant point of tenderness over the diverticulum.

TABLE 8—RESULTS OF TREATMENT OF CONGENITAL DEFECTS OF THE DUODENUM IN THE VANDERBILT CLINIC—PRESBYTERIAN HOSPITAL SERIES

	Cases	Cured	Improved	Failures	Not followed
Medically treated	57	2	14	~	31
Surgically treated	5	2	3	1	0
Total	62	4	18	8	31

ing degree may be noted. Most of the diverticula show no pathology other than the abnormal sac-like process and defective muscular layers.

**Symptomatology**—In the series of 57 cases (Table 9) from the Presbyterian Hospital 30 were casual findings in the course of a barium study of the gastrointestinal

**Diagnosis**—As in the majority of cases of duodenal lesion the barium meal with fluoroscopy is the most dependable and usually the only means of diagnosis. Fluoroscopy is much more reliable than roentgenographic study but both should be made. Films showing a barium retention of six hours and more prove that there is delayed

TABLE 9—ANALYSIS OF 57 CASES OF DUODENAL DIVERTICULA STUDIED AT THE PRESBYTERIAN HOSPITAL

	Males	Females	1st portion	2nd portion	Discovered accidentally	Cured	Improved	Failure	Discovered at autopsy	Dead	Not followed	Site of lesion			
												1st portion	2nd portion	3rd portion	4th portion
Medically treated	12	31	15	16	22	0	10	4	5	6	18	2	20	7	3
Surgically treated	3	11	8	5	8	7	1	0	3*	3*	3	2	8	3	1
Total	15	42	23	21	30	7	16	4	8	9	21	4	28	10	4

\* The patients were operated on for lesions other than diverticulum.

tract for other lesions. 28 lesions other than diverticula were found by x-ray examination or at operation in this series. One may safely say that only about half of the diverticula cause symptoms. These are equally divided between those of digestive disturbances (such as belching and upper abdominal distress) and real pain epigastric or

emptying. X-ray studies differentiate this lesion from other duodenal, gastric and biliary tract disorders with which its symptoms are most often confused.

**Treatment**—If the diverticulum empties easily, shows no six hour residue and is not tender on direct palpation then in all probability it is harmless and no therapy is

needed. If it retains barium is placed dependently and is tender to pressure an ambulatory ulcer diet and ulcer regime with or without gastric lavage should be given a thorough trial. If these measures fail and tenderness and signs of inflammation (a diverticulitis) persist surgical removal is indicated.

**Prognosis**—Of the 7 patients in this series operated on for diverticulum all were cured of their symptoms. Five of the diverticula were excised, 2 were inverted into the duodenum and the base closed because it impinged on the papilla of Vater. Operation for removal of a diverticulum if any other pathologic condition is present will result in a continuance of symptoms.

### ACUTE DUODENAL OBSTRUCTION

(*Acute Duodenal Ileus, Acute Arterio-mesenteric Ileus, Acute Gastromesenteric Ileus*)

**Definition**—An acute obstruction of the duodenal lumen as a result of pressure from outside or within the wall of the duodenum.

**Etiology**—The most common cause of acute duodenal obstruction is considered to be the angulation of the third or preapertic portion of the duodenum by the superior mesenteric vessels. Visceroptosis and atony of the duodenum are predisposing factors as is the flat dorsal or recumbent position. Hemorrhage into the wall of the duodenum into the pancreas or into the periduodenal tissues or edema of the pancreas may shut off the lumen of the duodenum. Resection of the duodenum with duodenorrhaphy may cause narrowing or angulation sufficient to result in acute obstruction.

**Pathology**—The duodenum is found to be acutely dilated with an associated acute dilatation of the stomach with an acute angulation at the point of the duodenum where the superior mesenteric vessels cross it. As the duodenum fills the angulation increases especially if the walls are atonic. There may be hemorrhages in the wall of the duodenum. If the hemorrhage is massive as in jaundice or when associated with pancreatitis the lumen of the duodenum may be obliterated.

The pancreatic secretions and bile of which each averages from 800 to 1000 cc in

twenty-four hours as well as the gastric secretions tend to cause rapid dilatation of the stomach and duodenum proximal to the obstruction.

**Symptomatology**—The patient presents all the symptoms and signs of a high intestinal obstruction: *i. e.*, great prostration, restlessness, rapid pulse, repeated vomiting of large amounts of bile stained fluid with later fairly constant spilling over of the same material. This results in rapid dehydration and loss of sodium and chlorine radicals as shown by electrolytic studies of the blood leading to tetany, decreased urinary output and death.

**Physical Signs**—Distention of the upper part of the abdomen with succussion sounds is characteristic. Gastric lavage reveals large amounts of gas and stomach and duodenal contents which may amount to from 2 to 4 liters. The patient appears restless, pinched and dehydrated and has an increasingly rapid pulse.

**Treatment**—In the cases caused by angulation of the superior mesenteric vessel placing the patient in the head-down prone position and lavage with water at a temperature of 110° F. will usually produce prompt and curative results. Intravenous infusion of Ringer's or normal salt solution to combat base loss is essential. If the lumen of the duodenum is obstructed by pressure from without or by causes in the wall of the duodenum a gastroenterostomy may prove effective as a short-circuiting procedure.

**Prognosis**—Unless the angulation of obstruction is relieved within the first twenty-four hours the patient shows a rapid downhill course. It is extremely important to recognize the condition early and apply remedial measures promptly to prevent death.

### CHRONIC DUODENAL STASIS

**Synonyms**—Chronic duodenal ileus, chronic duodenal dilatation, chronic duodenal obstruction, chronic duodenal retention.

**Definition**—A constant or recurrent delay in the passage of duodenal contents with or without dilatation and with or without demonstrable mechanical obstruction.

**Etiology**—When chronic duodenal stasis is associated with mechanical obstruction the latter may be the result of congenital or

acquired bands or adhesions of pressure of the superior mesenteric vessels or of angulation associated with an anomaly of curvature or rotation of the duodenum. The obstruction may be caused by pressure from without or inside the wall of the duodenum by a tumor or inflammatory scar tissue.

Chronic duodenal stasis occurs without any demonstrable organic cause of obstruction. The reverse peristalsis and atony can be explained only on a neurogenic basis reflex or inhibitory impulses interfering with the normal physiologic movements of the duodenum. These cases are the most difficult to explain and the most unsatisfactory from the therapeutic standpoint.

**Pathology**—In the cases associated with organic obstruction the pathology varies with the factors mentioned under etiology. The mere presence of veil-like adhesions does not constitute a mechanical obstruction but any of the following constitutes a valid pathologic condition: the definite angulation as a result of a band of fibrous tissue congenital or inflammatory, a congenital anomaly of curvature or rotation or of pressure of superior mesenteric vessels, a cicatricial stenosis secondary to ulcer, or pressure from without or within the wall of the duodenum as a result of neoplasm.

In these cases as well as in those in which no organic obstruction is demonstrable there is a varying degree of dilatation. In the former, especially with a gradually increasing obstruction—as in stricture of a jejunal ulcer—the walls of the duodenum are hypertrophied.

**Symptomatology**—In comparing the major symptoms of the patients with organic obstruction and those without real obstruction (Table 10), it will be seen that they are common to both conditions in two particulars; do they differ? In duodenal stasis due to real mechanical obstruction with gradual narrowing of the lumen the vomiting is more constant without periods of well-being. In duodenal stasis without demonstrable obstruction the vomiting pain or epigastric distress and other digestive disturbances come on in an attack associated with emotional disturbances or fatigue and followed by an interval of freedom from symptoms. In these cases it will be noted that the anxiety factor is demonstrated in a

far greater proportion. Furthermore there is a higher incidence of asthenic and plotic habitus in this group.

Physical signs are not at all characteristic except in the cases in which there is gradually increasing duodenal stenosis with a markedly dilated hypertrophied duodenum. Here right upper quadrant distention succussion and splashing can be made out.

**Diagnosis**—The most reliable and the essential diagnostic measure is the barium meal with fluoroscopy. Roentgenograms may or may not show dilatation and will not show the reverse peristalsis revealed by fluoroscopy. An experienced roentgenologist can usually demonstrate real organic obstruction and predict the findings at operation. A study of these cases by internist roentgenologist and surgeon is essential if errors in diagnosis and therapy are to be avoided.

The lesions to be differentiated largely by roentgen study, are gastric and duodenal ulcer, gastric carcinoma, disease of the gall bladder, pancreatic inflammation, cysts and tumors.

In the cases in which organic obstruction due to ulcer stenosis of definite constant narrowing by congenital or acquired bands is demonstrated in the fluoroscopic studies medical therapy as outlined by Crump should first be tried. If there is an underlying anxiety factor, this should be dealt with by the physician experienced in psychoanalysis. After a thorough trial at conservative measures especially if obstruction is shown to be increasing surgical treatment is indicated. A release of the obstruction or angulation by sectioning fibrous bands most commonly hepatoduodenal may be all that is required. If the obstruction can be demonstrated in the third or fourth terminal portions or if it is due to stenosis of the jejunum just distal to the duodenojejunal junction duodenojejunostomy is the correct operation. Gastroenterostomy is not as physiologic does not give as direct short circuiting and in the follow up studies shows unsatisfactory results.

**Prognosis**—In these cases the prognosis depends on whether the duodenal stasis is caused by organic obstruction or is a functional affair. In the latter group psychotherapy is more important than all other

TABLE 10.—*Summary of the symptoms and Roentgen findings in cases of duodenal stasis with and without demonstrable obstruction*

	Number of patients	Average age, years	Males	Females	Range in chronicity of symptoms	Indigestion	Bloating and belching	Headaches and dizziness	Pain	Pain, epigastric	Pain in right upper quadrant	Periumbilical pain	Nausea	Vomiting	Constipation	"Nervousness"	Definite anxiety factor	Onset with infection	Loss of weight	Pituitic habitus	Obese habitus	Roentgenographic findings					
Chronic duodenal stasis with demonstrable obstruction	30	56	14	22	3 wks to 25 yrs	11	5	4	26	19	1	4	10	19	10	10	19	2	16	18	2	Duodenal delay	Duodenal dilatation	Liver enlargement	Duodenal mesenteric	Duodenal anomaly	Gastric residue
Chronic duodenal stasis with demonstrable obstruction	50	57	18	59	4 wks to 10 yrs	23	21	1	33	21	0	6	23	23	22	8	10	4	5	20	3	51	24	14	3	4	6

measures. The anxiety factor should be dealt with in the same way if it exists in the cases showing mechanical obstruction. Table 11 shows the results in therapy in the series from the Presbyterian Hospital. The author is convinced that many of the results hitherto published are too optimistic, because not based on careful or prolonged follow-up studies.

### DUODENAL FISTULA

**Varieties.**—There are two varieties of duodenal fistula, the external and the internal.

**Definition.**—A duodenal fistula is a tract which communicates between the lumen of the duodenum and some other viscus or the

there is no obstruction to the normal lumen of either viscus which enters into the fistula.

**Symptomatology.**—Symptoms are usually absent. If the duodenum communicates with the colon, rapid loss of weight and strength will result. The patient will have diarrhea, and the stools will contain large amounts of bile. There may be fecal-smelling vomitus.

**Diagnosis.**—Except for the rare communication between the duodenum and another part of the intestinal tract, discovered by barium roentgenographic studies, these fistulas are undiagnosed unless the patient is operated on or comes to autopsy.

**Treatment.**—If x-ray studies show a communication between the duodenum and the

TABLE 11.—RESUMÉ OF THE RESULTS OBTAINED IN CASES OF CHRONIC DUODENAL STASIS

	Medically treated cases.	Cured	Improved.	Failures	Deaths	Cases not followed	Surgically treated cases.	Cured	Improved	Failures	Deaths	Cases not followed	Operative findings		Procedure			
													Hepatoduodenal band Obstruction or angulation by superior mesenteric vessels	Section of band	Duodenoduodenostomy	Gastroenterostomy	Duodenoduodenostomy or duodenoduodenostomy	
Chronic duodenal stasis with not demonstrable obstruction	26	4	9	5	1	7	13	2	1	6	4	0			5	2	6	
Chronic duodenal stasis with demonstrable obstruction	30	2	6	6	0	16	25	11	2	6	0	4	13	5	15	7	0	5

outside surface of the body. The former is termed an internal and the latter an external duodenal fistula.

**1. Internal Duodenal Fistula.**—**Etiology.**—The most common cause is a gallstone ulcerating through the wall of the gallbladder and the adjacent adherent duodenum. An ulcerative process between the duodenum and some other part of the adjacent intestinal tract may result in an internal fistula.

**Pathology.**—If the internal fistula unites the duodenum with the gallbladder, it will remain open if bile continues to flow through the fistula owing to obstruction of the common duct below the cystic duct. The tendency is for an internal fistula to close if

colon or ileum, and especially if the patient has diarrhea and has rapidly lost weight and strength, an operation to close the fistula is definitely indicated. The other varieties, as a rule, give no symptoms. If disease of the gallbladder is present, surgical treatment may be necessary, and the duodenal opening can be attended to at the same time.

**Prognosis.**—The closure of an internal duodenal fistula is usually an easy procedure. The results are excellent in closure of a fistula between the duodenum and the gallbladder, this being done by removing the gallbladder and closing the opening into the duodenum. In duodenocolic fistula the patient is often greatly depleted, and the dan-



gers of an external colic or an external duodenal fistula following an attempt to close the internal fistula compromise the recovery.

**2 External Duodenal Fistula—Etiology**—The most common cause is disruption of the inversion of the duodenal stump following resection of the stomach for ulcer or cancer. Owing to the edema of the gastrojejunostomy or angulation of the stomach the contents of the duodenum—bile and pancreatic fluid—rapidly accumulate and burst the duodenal stump. Other causes are insecure closure of an incision into the duodenum for excision of ulcer, the inadvertent application of a clamp to the duodenal wall during a right nephrectomy, and insecure anastomosis of the duodenum to the common duct or gallbladder for the relief of obstruction of the common duct.

**Pathology**—Because of the digestive action of duodenal contents activated pancreatic ferments the walling-off process of the peritoneum is greatly compromised and subperitoneal and subcutaneous tissues and skin between the duodenum and body surface undergo digestion. Unless this action is checked by neutralizing the ferments or by sucking out the duodenal contents the area around the fistula enlarges and wide raw painful skin surfaces are exposed to the proteolytic pancreatic juice.

The loss of fluid and especially of base in the duodenal contents results in very rapid dehydration and changes in the electrolytes of the blood.

**Symptomatology**—There is no more serious complication in abdominal operations except for massive hemorrhage than an external duodenal fistula. It usually complicates a serious operation and develops as a rule within the first few critical days of convalescence. A copious bile stained fluid flowing from the operative incision or drainage tract is usually the first sign of the establishment of the fistula. The patient complains of thirst and rapidly becomes dehydrated. Fluids such as milk or thin gruel appear in the fistulous tract promptly after ingestion. The peripheral skin rapidly becomes irritated and painful and soon shows proteolytic digestion. As dehydration increases the urinary output decreases. Examination of the blood shows a decrease in chlorides and a change in the proportion of

the electrolytes of the blood is noted. Within twenty four hours the patient may become extremely weak and thirsty, has a rapid pulse and has a pinched look. Tetany may develop as a result of the loss of bases in the blood.

**Treatment**—It is essential to recognize this complication promptly. Three measures offer the most definite relief. 1 Sodium chloride should be supplied intravenously or subcutaneously in the form of sterile Ringer's solution or normal salt solution. A continuous intravenous drip to supply the patient with 3000 or 4000 cc of salt solution is the surest method. 2 A jejunostomy by means of a No. 18 or 20 F catheter should be made through which the patient can be given glucose solution and peptonized milk in 100 cc amounts every four hours. 3 The patient should have dressings removed and by means of a frame over the abdomen covered with a blanket or sheet continuous suction should be established to draw up the duodenal contents as they well into the fistulous opening. An electric light bulb kept a foot or so above the surface of the skin will provide warmth and keep the skin surface dry around the fistula. This avoids continuous painful changing of dressings and keeps the patient warm and comfortable. Attempts to close the fistula especially if it is on the posterior surface are useless.

**Prognosis**—From 40 to 50 per cent of the patients die unless promptly and properly treated. The fistula closes within two or three weeks if the patient survives the first week.

### DUODENITIS

Duodenitis is a lesion that is difficult to define. It has no known etiology, the pathology is not well understood and the symptoms are easily confused with those of duodenal ulcer, diverticulum and disease of the gallbladder. Both the treatment and the prognosis are as yet poorly defined and uncertain.

Within recent years some surgeons and roentgenologists have described a condition characterized by marked reduplication of the duodenal mucosal fold especially of the bulb and irritability and tenderness over the duodenum as seen in the barium meal examination and have called it duodenitis. The patient gives a history suggestive of a du-

duodenal ulcer or duodenal polyp. In many cases operation is performed with the diagnosis of duodenal or gastric polyp because of the redundant mucosa obstructing the pylorus. The treatment that is indicated when this condition is found at operation is a modified Finney pyloroplasty with excision of part of the pyloric ring.

In the few cases in which operation was performed in the Presbyterian Hospital an incorrect diagnosis of duodenal polyp was made.

#### FOREIGN BODY IN THE DUODENUM

Sharp objects like pins or needles or fish bones may become embedded in the duodenum and may necessitate removal. One of the patients at the Presbyterian Hospital was brought in as an emergency case from a nearby otolaryngologic hospital and had a radium tube in the lowermost portion of the duodenum. This of course required immediate operative removal.

The majority of patients can be watched safely for a few hours to note the progress of the object beyond the duodenum. As a rule the object even when sharp is passed per rectum. If by x-ray study it is seen to remain in a fixed position in the duodenum, operative removal is indicated.

#### TUMORS OF THE DUODENUM

Tumors of the duodenum are as rare as tumors of the stomach are common. In the Presbyterian Hospital series the author could find only 13 cases reported. Raiford, in reporting the cases of tumors of the small

and palliative gastroenterostomy for relief of duodenal obstruction is the only relief that surgery can offer. Carcinoma of the papilla of Vater is at times a debatable lesion; some pathologists considering that certain of these are of duodenal mucosal origin. These cases have not been included in this group as the great majority involve the common duct and pancreas before they do the duodenum.

Duodenal polyp gives the sentinel symptom of hemorrhage. Patients are given a barium meal to determine the source of hemorrhage, being considered as having an ulcer, and the diagnosis of polyp is made. The majority of these polyps occur in the first portion of the duodenum and may be so pedunculated as to pass through the pylorus. They may or may not be associated with pain. Polyps are easily removed through an opening in the duodenum and show no tendency to recur.

ALLEN O. WHITTLE

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TABLE 12.—PRIMARY TUMORS OF THE DUODENUM IN THE PRESBYTERIAN HOSPITAL SERIES

Polyp	5
Lipoma	1
Adenocarcinoma	0
Sarcoma	2
Heterologous pancreas	3
Total	11

intestine from the Johns Hopkins Hospital series found 88, 21 of which were tumors of the duodenum. Table 12 shows the cases of tumors in the Presbyterian Hospital series. Fortunately, polyps are the most common and excision gives excellent results. Carcinoma and sarcoma are as a rule inoperable.

## DUODENAL ULCER

**Incidence**—Since the beginning of the century when Moynihan first stressed its incidence duodenal ulcer has been recognized as a rather common cause of indigestion. Some authorities claim that about 1 in 10 of the adult population at some time suffers from a duodenal ulcer. The condition is much more common in males than in females; combined figures from several large clinics showing 79 per cent males. Duodenal ulcer may be found in patients of any age but it is most frequent in the third and fourth decades. Several cases of its occurrence in infancy and childhood are recorded in the literature. The question of influence of occupation on the incidence of duodenal ulcer is debatable but exacerbations do occur under conditions of nervous stress and increased activity. In this connection it is well known how frequently duodenal ulcer occurs in physicians who as a class are subjected to the nervous tension of assuming grave responsibilities. In a series of cases of duodenal ulcer occurring in the city of New York the occupation most frequently noted was that of taxi driver. It would be difficult to imagine a more trying stress and strain occupation than this when associated with the relentless competition that prevails in a large city.

**Varieties**—1 Acute duodenal ulcer which is limited to the mucous membrane occurs as a complication of some acute or chronic infection and its existence is likely to be overlooked except in the comparatively rare case in which the process progresses and hemorrhage or perforation occurs. Duodenal ulcer as a complication of superficial burns described in 1842 by Curling is present in a relatively small percent age of cases.

2 Chronic duodenal ulcer which penetrates deeper into or even through the wall and is associated with extensive reactive tissue changes is the common form encountered.

**Etiology**—The pathogenesis of peptic ulcer has been diligently and intelligently studied both clinically and experimentally by many able investigators. However as pointed out by Boyd the mere fact that an ulcer can be produced in the laboratory by some ingenious method need not necessarily

bear any relation to the causation of the common peptic ulcer of actual practice.

The hereditary factor at times is important. Alvarez in his splendid study of this problem of etiology describes as the ulcer type the keen alert sensitive man who is constantly driving himself (this description is substantiated by ample clinical proof).

It is evident that any nutritive injury to the duodenal mucosa from any cause whatever makes possible a digestion of tissue and thereby gives rise to ulcer. Erosion of the mucosa may follow irritation by means of chemical physical or mechanical trauma. Bergsma reports a high incidence of ulcer in Abyssinia where the food is heavily peppered, and Sommervell and McCarrison have pointed out that in parts of southern India there is a frequency of ulcer supposedly due to a diet of tapioca.

Local and alimentary infections undoubtedly play an important part. Rosenow has produced duodenal ulceration by intravenous injections of large numbers of certain strains of streptococci. Cushman has called attention to the flare-up in the symptoms of ulcer caused by the common cold and has pointed out that gastric hemorrhage often follows an attack of influenza or sinusitis.

Arterial changes are probably a factor. Reeves has called attention to the fact that anatomically the duodenal cap is poorly supplied with blood and he has demonstrated that the vessels of the first part of the duodenum are delicate and long with an arrangement that probably predisposes to thrombosis. The influence of vasomotor spasm in the production of relapses of duodenal ulcer has been emphasized by von Bergmann.

The experimental work of Mann and Williamson, Bruce, Morton, Matthews and Dragstedt has definitely shown that whatever may be the cause or causes of local necrosis the digestive action of the gastric juice is the important factor in the conversion of an area of necrosis into an actual ulcer. Ulceration of the duodenum and stomach has been produced experimentally in animals by Walpole and others. Histamine in beeswax was implanted in the muscles and the effects were attributed to the prolonged sustained secretion of an acid gastric juice.

The influence of the nervous system in the etiology of ulcer is no doubt vital especially with respect to the derangement of the normal protective mechanism against ulcer. The presence of an ulcer diathesis (Hurst) is generally recognized and the increase of motor and secretory activity of the stomach is characteristic of the person with duodenal ulcer. The predisposing factor establishing the so called duodenal stomach (Gray) is the relative increase in vagus excitation established by diminished sympathetic control or by increased vagus stimulation. Crile has called attention to the importance of nervous stimulation in these cases. Cushing calls attention to the part that the interbrain plays in connection with the parasympathetic system and emphasizes the relation between peptic ulcer and stimulation of the interbrain. Robertson and Hargis observed a common occurrence of ulcers in patients dying of exophthalmic goiter. Langley has shown that nicotine paralyzes the synapses of the sympathetic nervous system and the influence of excessive use of tobacco on patients with ulcer has been commented on by many observers.

While the initial production of duodenal ulcer may be understood the factor or factors in the persistence of the ulcer or its tendency to recurrence have not been adequately explained by either clinical or laboratory investigators. However with regard to the problem of recurrence it is advisable to study the anthropologic type of the patient in his reactions as well as the gastric juice and the manner in which it is secreted (Alvarez).

Ochsner, Gage and Hosoi in 1936 published an excellent review on the etiologic factors. They divide the causes into two groups: (1) predisposing factors which include tissue susceptibility and constitutional predisposition and (2) precipitating factors which consist of hypersecretion, hyperacidity, focal infection and gastric trauma.

Two factors emerge as having a major role in any consideration of the etiology of duodenal ulceration: the persistent hyperacidity and hypersecretion throughout the whole twenty-four hours and the exposure of the duodenal mucosa to a small stream of acid—the jet mechanism. This may have a bearing on the relative infrequency in wo-

men because they possess a flatter type of duodenum which allows more certain quick neutralization of the acid.

**Pathology**—Acute ulcers may be irregularly distributed in the duodenum and may be multiple. These have a natural tendency to heal rapidly although perforation or hemorrhage may occur.

Chronic duodenal ulcers are almost always situated in the suprapapillary region within 5 cm. of the pylorus where they are exposed to the action of the unneutralized acid gastric juice. They may arise on the anterior or posterior wall or on both walls. They are usually small and punctate and show little tendency to induration. Caloused duodenal ulcers are not uncommon however and if anterior they tend to become adherent to the liver but if posterior they tend to become adherent to the pancreas. M. J. Stewart reports that ulcers of the posterior wall are usually one and one-half times the size of those on the anterior wall. The ulcers are usually rounded or oval, irregularity in shape occurring at times in the smaller ones. The characteristics of the crater margin, floor and walls as well as the serosal aspects depend on whether the ulcer is active, indolent or healing. The chronic indolent ulcer may have thickened undermined edges, an indurated floor and a sloping wall while the more acute form may have a punched-out appearance with soft congested walls and floor. The serosa in chronic ulcer is usually thickened and whitish stippling may be observed.

In the pathologic course of a chronic duodenal ulcer the following may occur:

1. **Healing**—This may occur without further serious change leaving a smooth scar.
2. **Perforation**—This may be acute especially if the ulcer is situated on the anterior wall. Chronic perforation of the posterior wall with involvement of the pancreas is not uncommon.

3. **Erosion of blood vessels**—The superior pancreaticoduodenal and the gastroduodenal arteries may be involved in ulcers of the posterior wall causing hemorrhage.

4. **Cicatrization with stenosis**—Duodenal occlusion may occur with dilatation of the stomach. Stenosis of the ampulla of Vater with obstruction of the outflow of bile and pancreatic juice has been reported.

5 Periduodenal adhesions Periduodenitis with adhesions to surrounding structures and viscera is common Occasionally diverticula of the duodenum may follow cicatrization of an ulcer

6 Malignant change This is extremely rare in cases of duodenal ulcer although some cases have been reported

Statistics do not agree as to the frequency with which ulcer of the duodenum is accompanied by gastric ulcer M J Stewart in 4000 consecutive autopsies including 153 cases of active duodenal ulcer and 89 cases of gastric ulcer found only 2.6 per cent of the chronic duodenal lesions to be accompanied by chronic lesions in the stomach Wilkie in a series of 300 patients with ulcer on whom he operated found coincident gastric and duodenal ulcers in 49 cases (14 per cent) Walters in a study of the antrums of stomachs removed at the Mayo Clinic by partial gastric resection for duodenal ulcer found a very infrequent association of gastritis

**Symptoms**—An *acute ulcer* of the duodenum usually does not give rise to symptoms unless perforation or hemorrhage occurs It is usually so superficial that no local or distant reflexes are excited by irritation and the inflammatory reaction is scant

The history of *chronic duodenal ulcer* is usually a long one in which there have been remissions often with complete relief from symptoms Periodicity may be marked and the attacks appear to be more frequent in *autumn and spring* *Nervous and physical fatigue* or an infection of the respiratory tract may initiate an attack but probably the most common of all exciting causes is dietary indiscretion Excessive use of alcohol or tobacco is also an important factor

The most constant and distinctive feature of ulcer is pain Its character varies It may be burning boring aching or gnawing in some cases it amounts to no more than a vague sense of pressure in the abdomen Moynihan described it as hunger pain since it is felt particularly when the stomach is empty coming on from one to six hours after a meal the interval often being in direct ratio to the size of the meal and being relieved by ingestion of food or alkali or by self induced vomiting It is not unusual for the patient to be awakened by pain in the

early morning hours Pain coming on in the night suggests obstruction Pain is usually felt in the midline or just to the right often being localized midway between the xiphoid and the umbilicus although it may radiate to the back or sides Radiation of pain is frequent in cases of penetrating or stenosing ulcer Wilkie stated that an atypical history without hunger pain is more common in women than in men being present in 35 per cent of 94 cases of duodenal ulcer in females studied by him Nausea and vomiting are infrequent in uncomplicated cases but the regurgitation of sour liquid is not uncommon Relief obtained from vomiting may cause the act to be repeated so often that the patient may regard it as a symptom

In the absence of definite hemorrhage anemia does not usually develop although the presence of occult blood in the stools may be constant occasionally slight persistent oozing may cause secondary anemia About 25 per cent of patients with duodenal ulcer have bleeding as evidenced by tarry stools or the presence of occult blood Disordered bowel function and loss of weight are not marked in uncomplicated cases although there may be constipation Latency in production of symptoms is not rare in cases of duodenal ulcer and severe hemorrhage or acute perforation may be the first symptom noted

**Physical Signs**—The uncomplicated duodenal ulcer is characterized by a lack of physical signs The chief value of physical signs in duodenal ulcer is in the exclusion of conditions simulating ulcer and in the disclosure of possible foci of infection Localized tenderness in the central or right lateral portion of the upper part of the abdomen may be present If marked it suggests that the ulcer is inflamed adherent or penetrating Rigidity of the upper right rectus muscle may be observed owing to exaggeration of the upper abdominal reflex but it is by no means a constant finding In the presence of complications the physical signs are usually quite characteristic of the existing condition

**Special Examinations.**—*Gastric Analysis*—The fractional test meal usually shows a tendency to hyperchlorhydria or high normal acidity curves in uncomplicated cases of chronic duodenal ulcer In some cases there is evidence of normal or rapid

emptying of the stomach with continuous after-secretion. The specimens may contain chemical or microscopic evidence of blood.

**Röntgenologic Studies.**—If properly performed and correctly interpreted, these will reveal the presence of an ulcer in a very large percentage of cases. A fluoroscopic examination should always be made. A niche in the duodenal bulb caused by the crater of an ulcer or deformity of the duodenal contour due to cicatricial contraction, with evidence of a combination of retention and hyperperistalsis in an otherwise normal stomach, is the usual finding. The rugae may assume a star-like pattern, owing to the scar tissue contracture in the region of the ulceration.

simulated by those of other lesions, and the laboratory and roentgenologic studies may be confusing. A complete and comprehensive history, especially with respect to discomfort or pain; careful clinical observation; a thorough physical examination, to rule out conditions which may mimic ulcer; a careful laboratory study, especially the fractional test meal, and a competent roentgenologic examination will in most cases establish a correct diagnosis. The differential diagnosis between duodenal ulcer and functional nervous gastric disorders is frequently difficult. Symptoms identical with those produced by an active ulcer may be complained of by the patient possessing a gastric and nervous

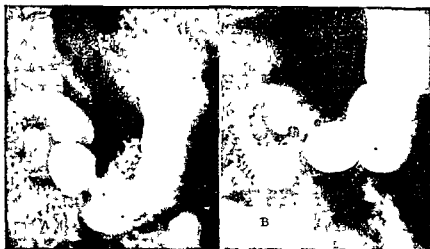


Fig 519—A, Normal duodenal bulb. Contraction wave in the stomach approaching the pylorus. The pyloric sulcus indicates the division between the stomach and the duodenum. The normal bulb resembles an ace of spades. B, An unusually clear demonstration of a duodenal ulcer. Ulcer of the lesser curvature side of the duodenal bulb with an annular indurated area surrounding the ulcer crater. Opposite the ulcer crater on the greater curvature side is a spastic indrawing of the wall of the duodenum. (Courtesy of Dr. Earl R. Crowder.)

Vaughan and Singer have pointed out the value of roentgenograms in the diagnosis of perforated peptic ulcer through detection of spontaneous pneumoperitoneum. Ulcers on the posterior duodenal wall are especially difficult to visualize. Their presence may sometimes be determined by the spot of barium left in the crater after the main part of the barium meal has passed on.

**Stool Examination.**—After a meat-free diet for forty-eight hours the stool should be examined in all cases to detect the presence or absence of fresh or occult blood.

**Diagnosis.**—The problem of arriving at a correct diagnosis of duodenal ulcer is frequently perplexing. The symptoms are often

constitution which predisposes to the development of ulcers. A roentgenologically normal duodenal bulb and persistent absence of occult blood in the stools establish a correct diagnosis in most instances. A routine neurologic examination must be carried out with great care for those patients in whom gastric crises of tabes must be considered.

Chronic appendicitis and cholecystitis, especially in the mild form, may give rise to reflex dyspepsia, with pain closely simulating that of ulcer. Less commonly, reflex gastric symptoms may be present in cases of organic lesions or adhesions of the colon, esophagus, prolapsed kidney, small epigastric hernia, pancreatic disease and intestinal

tuberculosis. The irregularity of the pain in its time of onset, intensity and mode of relief as well as the presence of positive physical signs indicative of the local condition are significant factors in arriving at a correct diagnosis. The not infrequent association of chronic cholecystitis and chronic appendicitis with duodenal ulcer (chronic) must not be forgotten.

In cases of chronic duodenitis, chronic gastritis or both unassociated with actual duodenal ulceration but with symptoms suggestive of ulcer, careful and repeated roentgen examinations and gastric analysis are important factors in the differential diagnosis. The coexistence of these lesions with duodenal ulcer has been reported as occurring with varying percentages at different surgical clinics.

Mathieu in a study of 664 cases of carcinoma of the stomach found that in 8 per cent the symptoms quite closely simulated the typical symptoms of duodenal ulcer. He pointed out that the chief features that distinguish them from the symptoms of duodenal ulcer are the absence of spontaneous remissions and the severity of the pain from the onset.

**Prognosis**—The tendency to long duration of the condition and the ever present possibility of the development of dangerous complications, especially perforation, must be appreciated in attempting a prognosis in cases of duodenal ulcer. While in general the prognosis is good, the possibility of securing a permanent cure by a single course of medical treatment or a single surgical procedure is frequently quite uncertain. A reliable prognosis can be made only through an intelligent evaluation of the patient's nervous and mental make up, his habits and environment, his ability to cooperate, the type of treatment applicable to his condition, the stage of the disease in which treatment is instituted and the presence or absence of associated disease or complications.

**Complications**—Duodenal ulcer may be complicated by hemorrhage, perforation or obstruction. Infrequently gastric tetany and occlusion of the common or of the pancreatic ducts may occur. Malignant growths of the duodenum are so rare that for all practical purposes they can be dismissed.

**Hemorrhage**—The first indication of the

presence of a duodenal ulcer may be hemorrhage as evidenced by melena or hematemesis or both.

From hemorrhage of any moment some degree of faintness develops. Prompt recovery is the rule, however, and usually no further signs are present until the appearance of a tarry stool twenty-four hours later. Seldom does a single hemorrhage drive a patient to bed. Marked pallor, great thirst, restlessness, recurrent syncopal attacks, a rapid small pulse, sighing respirations, a fall in blood pressure and tarry stools indicate a massive hemorrhage. Usually several days elapse before the full extent of exsanguination is evidenced by examination of the blood, because capillary contraction keeps the blood concentrated. Frequent blood pressure readings probably constitute the best clinical indication of the intensity of hemorrhage. Sometimes the patient is found collapsed on the floor in a dead faint. When a patient is admitted because of hemorrhage from the upper portion of the gastrointestinal tract, the immediate question confronting the attending physician is regarding the source of the bleeding. Sometimes it is possible to obtain a history that indicates that a duodenal ulcer is the source. At other times the differential diagnosis is extremely difficult. Bleeding may be coming from esophageal varices or from gastric lesions due to gastritis, ulcer, benign or malignant neoplasms. In any case the patient is put to bed and attempts are made to keep him at complete rest. This means the judicious use of morphine to allay fear, reassurance of the patient and treatment for shock if necessary. The duodenum should be put at rest also by withholding fluid and food by mouth so that a clot may form and occlude the bleeding point. Fluids may be administered subcutaneously or by proctoclysis. Intravenous medication is to be avoided as it may raise the pressure sufficiently to dislodge a newly formed clot. Small transfusions of 30 to 75 cc. of blood may be used when anemia has reached an alarming level. This is more for the clotting effect than for the restoration of the blood volume. If the patient is young, bleeding usually ceases after a few days. When blood is no longer demonstrated in the stools, it is safe to resume feeding, carefully working up from fluids to a smooth

diet Recovery as a rule is rapid Rarely does the patient especially a young adult with chronic ulcer succumb to a first hemorrhage

The accumulation of blood in the colon and the distal portion of the ileum may cause toxemia due to all unimpaired digestion The temperature is elevated the pulse rate remains rapid and there is no desire for food Panchet suggests flushing the colon with a 2 per cent solution of sulfate of soda through a cecostomy It is quite apparent that rectal irrigation will not completely empty the proximal and midportion of the colon At autopsy the colon and the distal portion of the ileum may be filled with old blood, when it was evident clinically that death was not due to exsanguination

The source of blood in cases of chronic ulcer is generally an erosion of a small artery, and profuse hemorrhage rarely occurs from a chronic ulcer situated anywhere except in the posterior wall

Allen and Benedict in a study of 1804 patients with duodenal ulcer treated in the wards of the Massachusetts General Hospital found that 628 or approximately one third had gross bleeding Of these 401 per cent had minor bleeding without secondary anemia and 31.9 per cent bled severely enough to produce marked secondary anemia In this series over 3 per cent of all patients with gross bleeding eventually died of hemorrhage The mortality from sudden massive hemorrhage was 14.5 per cent, regardless of the treatment The most striking factor in determining the possibility of spontaneous recovery from hemorrhage in these cases was the age of the patient and these investigators concluded that spontaneous recovery is less likely with increasing age as death rarely occurred from hemorrhage in patients under fifty

There has been a tendency in some clinics recently to treat massive gastric hemorrhage without restriction of diet The patient is given purged food on a five meal daily schedule He is allowed as much food as he desires In addition alkalis atropine and iron are given The patient may move about in bed freely Meulengracht claims a greatly decreased mortality under this management This treatment may have sufficient merit to warrant a more widespread application

Balfour voiced what is probably the opin-

ion of most surgeons regarding immediate surgical treatment when he stated that the danger of succumbing to hemorrhage is less than the danger of operation during hemorrhage But it is a fact as stated by Allen that a small percentage of patients die from hemorrhage especially those who are older Consequently, it behooves the attending physician to keep this in mind and to be on the alert to detect the occasional case which will require surgical intervention as a life-saving measure even though the risk is great Gordon Taylor presents an excellent résumé on this difficult decision He declares that a policy of armed expectancy should be adopted even for a first hemorrhage as a large proportion of the fatalities are in this group Forty per cent of these deaths occur within the first three days

Hurst believes that the only indication for operation in the acute stage is the persistence of recurrence of severe hemorrhage while the patient is still fasting especially in individuals past middle life with a long history pointing to the presence of a chronic ulcer with arteries so degenerated that they are unlikely to contract sufficiently for satisfactory plugging by thrombosis

When the patient has recovered from the first hemorrhagic episode an attempt to demonstrate the ulcer by roentgen study should be made This may be safely carried out three weeks after cessation of hemorrhage In the event of a second hemorrhage from such a lesion operation should be urged after the patient has recovered and is in good condition This attitude is a safer one to assume than the risk of a succeeding serious hemorrhage The bleeding duodenal ulcer is usually on the posterior wall directly over a large vessel The erosion is often into the side of the vessel thus preventing it from retracting and stopping the hemorrhage In the older group of patients the lack of elasticity in the vessels is probably of moment

If surgical treatment is indicated the operation of election is exposure of the bleeding ulcer the cutting off of its blood supply by overlapping sutures about it or excision of the ulcer if feasible and in some instances at the discretion of the surgeon the performance of gastroenterostomy preferably posterior, if the condition of the patient was



rants it. In some instances a Finney-Haberer anastomosis is most successful.

**Perforation**—Perforations may be acute, subacute or chronic. The acute perforations may be further subdivided into gross and minute pinhole perforations.

Acute perforation may occur at any time and at any age but is most common between the ages of twenty-five and fifty. It is located on the anterior wall of the duodenum in most instances. It may follow the ingestion of a heavy meal or may occur during fasting. It has resulted from the manipulation of a barium meal in such instances perforation being apparent on the fluoroscopic screen. It may come on during exertion or it may happen while the patient is resting quietly in bed. When it follows exertion the patient often falls to the ground and cannot move without assistance. Perforation is initiated by sudden and severe localized epigastric pain which soon spreads over the entire abdomen and occasionally radiates to the chest, back or shoulders. There is marked pallor, the face is drawn, the skin is cold, the temperature is subnormal, respirations are shallow and the abdomen is retracted, soon manifesting board-like rigidity. Tenderness in the epigastrium is present immediately over the right side, tending to become generalized but remaining most marked over the epigastrium. The peritoneal insult is severe. The pulse rate may be but little elevated and often remains normal. From two to four hours after perforation the patient usually shows evidence of reaction from shock. Vomiting may occur and if it is repeated several times the vomitus may be streaked with blood. Rarely does frank hemorrhage occur with perforation. The temperature rises to normal, the pain is less marked, the facies suggests less distress, the color improves and the pulse becomes stronger. If the patient is seen at that time the diagnosis may be difficult, particularly if the typical history of ulcer is lacking. This period may be regarded as a delusive calm and it is at this time that the patient frequently is first seen by the physician and the diagnosis may not be made.

Biliary, renal or lead colic, acute hemorrhagic pancreatitis, mesenteric embolism or thrombosis, diaphragmatic pleurisy and ruptured ectopic gestation may present symp-

toms suggestive of acute perforated ulcer but the presence of associated signs characteristic of these conditions plus a carefully taken history usually establishes the diagnosis. Only the past history may suggest the correct diagnosis in cases of acute perforation of the gallbladder and of gangrenous cholecystitis.

The correct recognition of an acute abdominal emergency in which immediate operative treatment is required is the important point; the exact cause will be revealed at operation.

The symptoms of primary shock may pass off in a few minutes or may persist for a few hours, rarely longer. The patient improves generally, vomiting may cease and the abdominal signs may change but as a rule the tenderness and the rigidity persist with the same intensity. The dullness of the liver may be obliterated and roentgen examination may reveal pneumoperitoneum at that time. With abatement of intensity of the abdominal signs the diagnosis may prove to be quite confusing to one seeing the patient for the first time during the stage of reaction. The past and immediate history is important.

Twelve hours after perforation the patient's condition will again change with the advent of beginning peritonitis. Pain is more generalized and may be less severe; tenderness may be localized in the lower portion of the abdomen and the abdomen may show slight distention and may be softer. A mistaken diagnosis of appendicitis may be made at that stage.

The patient usually presents the typical picture of well-established peritonitis within twenty-four hours after perforation. Vomiting due to developing paralytic ileus usually is present. As a rule, death occurs within from two to four days if an operation is not performed.

The pinhole perforations are most difficult to evaluate. Many times the diagnosis is not made until operation has been carried out. The conditions confused with this are acute appendicitis, acute cholecystitis, pancreatitis, gastric crises of tabes and coronary occlusion.

The treatment of acute perforation is operative, once the primary shock has been combated. Operation within from four to six

hours of actual perforation offers the best prognosis. The duodenum is exposed and the perforation is closed and reinforced with a tab of omental or mesenteric fat if possible. The presence of food and gastric secretion in the peritoneal cavity may be ignored. But if it is possible to suck out this material it will not serve as a foreign body focus for subsequent infection. The prognosis for recovery depends on the time which has elapsed since perforation. Within the first twelve hours it is usually favorable as bacterial contamination of the peritoneum is rare until after this time. The surgeon should do as little as is consistent with the case in hand. This usually means simple closure of the perforation. More extensive operative treatment is contraindicated for several reasons. The terrain is most unfavorable for a complicated procedure. Complete disappearance of the ulcer follows in a fair number of cases. Complete relief of symptoms is obtained in 60 to 65 per cent according to White. In an additional 25 per cent of cases the patient will be comfortable on a medical regime. In other words only 10 to 15 per cent of those who have had a perforated ulcer will ever require additional surgical treatment. It follows that it is poor judgment to put an already jeopardized patient through the unnecessary risk of a radical operation.

Drainage is not necessary within the first twelve hours as the peritoneum will usually take care of any infection that is present. In the late cases sulfa drugs should be used and drainage of the lateral gutters should be reserved until an abscess is definitely diagnosed.

Generalized peritonitis and pulmonary complications are the major factors in the postoperative mortality.

In cases of subacute perforation the resulting peritonitis is strictly localized as a result of plugging of the perforation by a tag of omentum or protective fibrin. The symptoms are similar to those of acute perforation but less severe and are not followed by those of developing generalized peritonitis. The rigidity and tenderness of the abdomen are most marked in the vicinity of the duodenum and later become confined to a small area.

Spontaneous cure usually follows this

form of perforation but a localized abscess may form and rarely does generalized peritonitis result.

*Treatment of Subacute Perforation*—Rest and starvation often result in complete cure of the ulcer. If an abscess is forming surgical drainage should be deferred until it is well localized. Laparotomy should be performed only if the symptoms and signs indicate a tendency toward development of generalized peritonitis.

*Chronic perforation* of an ulcer of the posterior wall is common and is due to a slow penetrating process resulting usually in involvement of the pancreas. This gives rise to no unusual symptoms and the treatment is essentially the treatment of uncomplicated chronic duodenal ulcer.

The development of a duodenocutaneous or duodenovisceral fistula after perforation of an ulcer is extremely rare.

*Obstruction* in the duodenal bulb may be due to edema and congestion surrounding an active ulcer or to cicatricial stenosis. It is impossible clinically to distinguish obstruction due to spasm of the pyloric sphincter from obstruction due to edema or stenosis of the duodenal bulb.

Pain which is prolonged and especially marked at night and the vomiting of considerable food or excess gastric secretion at the end of the day are suggestive of obstruction. Hyperperistaltic action of the stomach occurs at first and may be distinctly felt by the patient or may even be visible. Later gastric atony develops and the stomach becomes a relaxed distended reservoir oftentimes with vomiting of food taken a day or more earlier. Progressive starvation and dehydration combined will result in extreme emaciation.

Characteristic symptoms and signs plus roentgenographic and gastric test meal studies easily establish the diagnosis of duodenal obstruction.

In the treatment of patients with obstruction the condition should be carefully studied and a trial of medical treatment given before operation is advised. Subsidence of edema in a patient with an active ulcer or relaxation of a spastic pyloric sphincter will often relieve the symptoms of obstruction.

If relief is not afforded by a careful medical regime then operative treatment may be

contemplated Preliminary medical treatment will tend to prepare the patient for operation. A gastrojejunostomy is often the operation offering the best results.

Tetany may result because of alkalo is in cases of obstruction and every means should be taken to combat the acid base unbalance before operation is attempted.

Occlusion of the bile or pancreatic duct may in rare instances develop as a result of extension of the inflammatory process or periduodenal adhesions. The surgical treatment depends on the coexisting lesions.

Malignant change in a duodenal ulcer is extremely rare but cases have been reported in the literature. If this condition is suspected partial gastric and duodenal resection should be performed in an attempt to control it.

**Treatment**—The treatment of complications having been discussed previously the treatment of a duodenal ulcer uncomplicated by hemorrhage perforation or obstruction will be considered here.

An acute ulcer if it manifests itself other than by acute perforation or hemorrhage should be subjected to medical treatment to which it will in most instances respond.

Successful treatment of the chronic and the recurrent duodenal ulcer is often a perplexing problem. In a consideration of the treatment of duodenal ulcer there are three salient facts that extensive clinical investigation has shown are well to bear in mind. The first of these is that the tendency to chronicity of a duodenal ulcer warrants the trial of a thorough detailed medical regime in the average uncomplicated case before operation is undertaken.

The second fact is that the tendency of the well regulated course of medical treatment to subdue attacks and remove symptoms causes the average patient to abandon wise precautions in the false belief that he has been cured. Many patients suffering from duodenal ulcer have neither the determination and patience nor the time inclination and means to follow out indefinitely the exacting routine of medical treatment.

The third and perhaps most important fact is that a certain surgical procedure which in one clinic will give brilliant results when employed for a certain type of ulcer will in another clinic when performed in

exact detail on the identical type of lesion give poor results. There are probably three reasons for this. In the first place it is well recognized that the tendency to recurrence is greater in the mentally alert, highly nervous physically active person especially if he is Jewish than it is in the more phlegmatic and unemotional person. In the second place it has been shown by Walters of the Mayo Clinic that duodenal ulcer and its associated lesions especially gastritis differ in proportion among different people and in different countries. Finally, a certain percentage of recurrences may be due to failure on the part of the surgeon to realize the importance of first eradicating all the accessible foci of infection and then impressing forcefully on the patient the vital importance of adhering strictly to the postoperative treatment, especially with respect to securing adequate mental and physical rest to avoid ing dietary indiscretions—such as overeating and alcoholic indulgence and to the avoidance of an excessive use of tobacco.

**Medical Treatment**—The physician assumes a definite responsibility in caring for these patients as the complications carry a decided threat. There is a medical mortality which must be considered in the final analysis. The etiology being unknown the treatment both medical and surgical must rest on accumulated experience. Once the diagnosis has been established medical treatment should first be instituted.

The principles of medical treatment are the eradication of foci of infection the securing of mental and physical relaxation the establishment of gastric and duodenal rest and the neutralization of acidity. This may be secured by rest in bed with freedom from worry and lessening of nervous tension through use of sedatives. During early treatment feedings in small amounts may be given hourly, and later the administration of small frequent meals may be instituted. The basis of the diet should be cream milk egg and cereal gruels. Medication as well as the diet is planned to keep the stomach free from acidity during a twelve-hour feeding period after which the stomach rests empty. Magnesium oxide or calcium carbonate depending on the degree of constipation present may be given alternately with small frequent meals. Olive oil is sometimes indicated

The activity of the ulcer is checked both clinically and by roentgenograms from time to time. When the patient resumes his usual life the eating of frequent small meals is essential and the prohibition of tobacco and alcohol is important. It is well to remember that during medical treatment complications may occur and that even when symptoms, signs and roentgenologic studies indicate a cure recurrence may follow.

**Surgical Treatment**—The surgical treatment for duodenal ulcer may be classed as follows:

- 1 Imperative—life saving
  - a Perforation
  - b Severe continuing hemorrhage

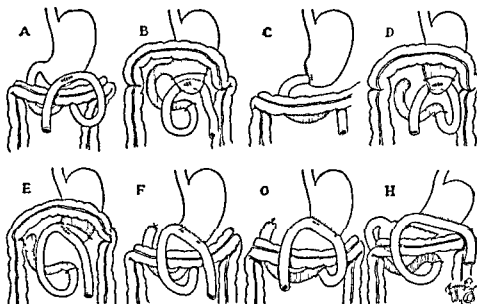


Fig. 550—Diagrammatic sketches of various gastric operations. A Anterior gastroenterostomy B posterior gastroenterostomy C Billroth's resection No. I D Billroth's resection No. II E Polya anastomosis F Balfour anastomosis G Moynihan anastomosis H Devine oblique partial gastric excision

- 2 Urgent
  - a Obstruction
  - b Repeated hemorrhages
- 3 Advisable—comfort bringing
  - a Persistent pain (local peritonitis adhesions to other organs)
  - b Unrelieved pyloric spasm
  - c Repeated failure of medical treatment
  - d When secondary to other foci (gallbladder appendix etc.)
- 4 Recommended
  - a Unwillingness or inability of patients to carry out necessary medical regime

The object of any form of surgical treatment is to seek to relieve pain to limit trauma (passage of rough food) to secure better drainage to put the affected part at rest and to eliminate possible foci of infection elsewhere which may have a bearing.

The surgeon should never begin the operation with a preconceived idea as to what he will do. He should be prepared to do any one of a dozen different operations which may best suit the individual case at hand.

There has been a tendency in recent years toward a more extensive type of operation for duodenal ulcer. Massive resections of the stomach to reduce the acidity and the hypersecretion have been recommended by Con-

nell, Zollinger and Wangensteen. This is a swing to the therapy advocated years ago by European clinics and a minority group of American surgeons. Friedell and his colleagues have shown that a permanent reduction of the free hydrochloric acid in fasting contents followed in 75 per cent of the cases in which half or more of the stomach had been removed including the pylorus and antrum. If it is admitted that continuous acid secretion removes the defensive neutralizing mechanism the operation seems logical.

Diagrammatic representations of various technical procedures which can be employed

are given in figure 550. In recent years there has been a trend away from the operation of posterior gastroenterostomy. This has been due in part to recurring troubles which have arisen ten to twenty years after the operation. Nevertheless there are occasions when this operation is the most simple and most effective one available. If the ulceration is acutely inflammatory and adherent so that mobilization is dangerous this simple by-passing type of operation is effective. It is also excellent when there is obstruction. A more direct attack on the ulcer has been advocated by some surgeons. Local excision with various types of pyloroplasty while seemingly resting on good physiologic principles has not been successful as a form of therapy. The tendency to radical partial gastrectomy for simple duodenal ulceration has had a recent vogue. It is now the operation of choice for duodenal ulceration when operation is indicated. The results to date seem to show that the mortality is no higher in good hands. The patients have been able to be less cautious as to diet, with little evidence of upset. At the present time there is no ideal operation for duodenal ulcer resection of the stomach being a formidable procedure at best.

After the operation the patient should eliminate from his life those factors which may bring about a recurrent ulcer or the reactivity of an old one. If the postoperative principles of adequate mental and physical rest, small frequent meals, avoidance of the use of alcohol and tobacco and adherence to a sensible diet are not followed recurrence may appear in spite of the type of operative procedure performed. Occasionally also in spite of an intelligent choice of operative procedure and strict postoperative precautions the ulcer may recur.

In estimating the end results of any treatment it is well to remember the natural history of duodenal ulcer. This condition is subject to fluctuation in symptoms. There may be periods of complete remission. It is also well to bear in mind that a patient who has had one ulcer is always a possible candidate for another.

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## XXVIII THE SMALL AND LARGE INTESTINE

### ANOMALIES OF THE SMALL INTESTINE

#### ATRESIA AND STENOSIS OF THE INTESTINE

##### Definition Etiology and Pathology —

Atresia of the intestine is a complete lack of intestinal continuity stenosis is a narrowing of the intestine Congenital atresia and stenosis of the small intestine are the result

ment during the solid stage (Fig 551) The cause of such arrests in development is still a matter of surmise Stenosis of the intestine represents an arrest of growth in a slightly later stage of development namely the stage of vacuolization and is manifested by a septum across the bowel with a small perforation in it (Fig 552) Such atresias and stenosis may occur at any point in the small intestine but are most commonly found in

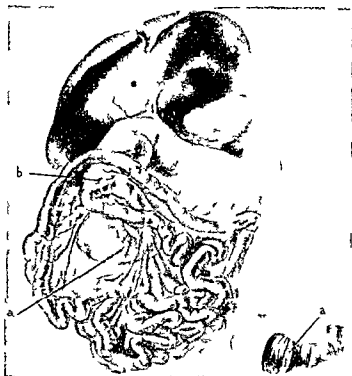


Fig 551—The septum across the duodenum a The result of the arrest of development at the solid stage, b duodenojejunosomy for relief of the duodenal obstruction caused by a \*

of an arrest in the development of the embryo at an early stage Prior to the fifth week of fetal life the intestine has acquired a lumen lined with epithelium Between the fifth and twelfth weeks the intestinal lumen becomes obliterated by epithelial confluence and changed into a solid cord By the twelfth week the solid cord has become vacuolized the vacuoles have coalesced and the intestinal lumen has become reestablished Atresia is the result of an arrest in develop-

ment of the ileum next in the duodenum and next in the jejunum fortunately they are seldom multiple The bowel above the obstruction becomes dilated and that below remains collapsed In the patient with atresia the bowel below the obstruction appears like a small hard cord though on examination it is found to contain all the normal elements including a lumen This lumen however may be only large enough to admit a

\* Ladd JAMA 107

small probe. In cases of stenosis the bowel below the point of obstruction is not as small as in the cases of atresia.

**Symptomatology.**—In the newborn infant the symptoms of atresia and stenosis are pain, restlessness, vomiting and lack of passage of normal meconium. On examination abdominal distention, visible peristalsis or coils of intestine and evidence of shock and dehydration are apparent. Exceptions to these usual findings may be noted in instances in which the obstruction is in the duodenum. In such cases the vomiting may



Fig. 50.—Roentgenogram of a patient with atresia of the duodenum which shows clearly the point of obstruction without the administration of barium.\*

be sufficiently effective so that the stomach and duodenum are thoroughly emptied and consequently no abdominal distention or peristalsis is seen. A roentgenogram taken without the administration of barium is of value in confirming the diagnosis. The point of obstruction may be clearly outlined by the air in the dilated loop of intestine above it. The administration of barium in a suspected case of atresia is contraindicated as it will block the small lumen of the intestine below the obstruction after an anastomosis has been performed and thus prevent recovery.

\* Ladd J.A.M.A., 101

ery. Another aid in confirming the diagnosis is the failure to find any keratinized cells in the stools (Farber).

**Treatment.**—When the diagnosis of congenital obstruction has been made the patient is prepared for operation by the parenteral administration of fluids to counteract dehydration and ketosis. For patients with duodenal obstruction a duodenojejunostomy is the operation of choice. A gastroyejunostomy may be performed in case the duodenal anastomosis is technically too difficult but the gastric operation is not so satisfactory. In patients with atresia lower down in the small intestine a lateral anastomosis should be performed by the special technique recommended by Ladd or that recommended by Webb and Wingensteen. The after-care is important and consists in maintaining the fluid requirements of the infant by administering glucose and saline solution parenterally, giving water and breast milk by mouth and aiding the dilation of the contracted bowel by means of saline enemas.

**Prognosis.**—Frazer in his book *Surgery of Childhood* states: "The prospect of recovery is exceedingly small. With improved technique and particularly with improved preoperative and postoperative care in well equipped children's hospitals the prognosis is much more favorable than it was a few years ago. In the Children's Hospital in Boston 99 patients with atresia and stenosis of the small intestine have been operated on with 29 recoveries."

#### MALROTATION AND NON-ROTATION OF THE INTESTINE

Incomplete rotation, malrotation and non-rotation are terms used to describe various abnormal abdominal conditions which are the result of arrest in fetal development during or after the return of the mid gut from the umbilical cord to the abdominal cavity. For an understanding of the conditions and for their successful treatment it is necessary to review some of the embryologic events which take place between the fifth and tenth weeks of fetal life. At approximately the fifth week of fetal life the abdominal viscera grow much more rapidly than the abdominal cavity with the result that there is insufficient room within the cavity to accommo-

date the organs which are destined to be located there. Nature meets this situation by temporarily transferring the mid gut: *e.* that portion of the intestine supplied by the superior mesenteric artery into the base of the umbilical cord. In other words a temporary normal omphalocele occurs which lasts from the fifth to the twelfth week of fetal life. During this period the rate of growth of the abdominal cavity is accelerated so that by the tenth week it has acquired sufficient size to reaccommodate its organs. The return of the mid gut to the abdomen takes place in a particular way. The prearterial segment or that portion of the intestine extending from the duodenum to the vitelline duct returns first and passes from right to left behind the artery. The postarterial segment or that portion of the mid gut from the vitelline duct to the middle of the transverse colon returns next and passes from left to right in front of the superior mesenteric artery. The next stage of development consists in the descent of the cecum to the right lower quadrant and the fusion of the visceral and parietal peritoneum to give the mesentery of the small intestine its oblique attachment to the posterior abdominal wall and the cecum and ascending colon their stabilizing attachment to the right side. An arrest in development may take place at almost any stage of this process (Fig 553). Thus the cecum may remain on the left side or under the ensiform or in the neighborhood of the gallbladder. These faulty positions may not of *themselves* be important or disturbing to the normal function of the bowel. It is only when there is a faulty position that pressure on one part or another of the bowel is likely to develop. Obstruction occurs and the condition becomes of importance necessitating relief by surgical intervention. In instances in which the development has been arrested before the parietal and visceral peritoneum were fused the mid gut remains attached to the posterior abdominal wall by only a very small area at the origin of the superior mesenteric artery. Under these circumstances a volvulus of the mid gut is particularly liable to develop. The twisting of the mid gut on itself with the origin of the superior mesenteric artery as a pivot is more likely to take place in a clockwise direction and may go

through an arc of 360 degrees or more. Of course the more it twists the more complete is the obstruction and the greater the interference with the blood supply of the bowel.

**Symptomatology**—The symptoms of the conditions found resulting from faulty rotation or volvulus of the mid gut are those of intestinal obstruction, namely vomiting, pain, restlessness and evidence of shock and dehydration. These symptoms may appear soon after birth or in contrast to congenital atresia and stenosis may not appear for months or even years and may be intermittent in character and of variable severity.

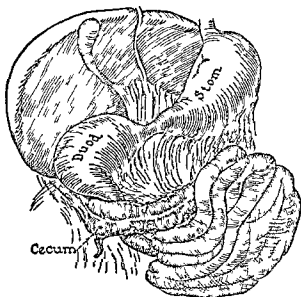


Fig 553.—Drawing showing the obstruction and dilatation of the duodenum caused by the mesenteric attachment of an unrotated and undescended cecum.\*

On examination abdominal distention and visible peristalsis are noted. It is to be remembered however that the obstruction takes place most commonly in the duodenum so that the distention is less marked than in other forms of intestinal obstruction lower down in the intestine. If the patient is not too acutely ill a barium enema with roentgen examination may be used to confirm the diagnosis. In the still less severe cases a barium meal and series of roentgen examinations may yield useful information.

**Treatment**—The treatment of these conditions is surgical. The operation may be one of the most confusing of abdominal operations and cannot be successfully carried out unless the embryologic development is

\*Ladd, *Pennsylvania M J* 34



kept in mind and operation is performed with a view to restoring normal physiologic function regardless of normal anatomical relations. Acidosis and dehydration are relieved preoperatively. In a case without volvulus the obstructed point is identified by the distended bowel above and the collapsed bowel below it. Suitable measures are taken to relieve the obstruction. In a case of volvulus of the mid gut the whole mid gut must be delivered out of the wound in order to ascertain the direction of the twist. The volvulus is then untwisted until no interference with circulation is apparent. The duodenum is then exposed in its entirety to insure free function and reduce the chances of recurrence. The cecum is usually placed in the left upper quadrant.

**Prognosis.**—In the Boston Children's Hospital there were 68 patients who had the type of operation advocated by Ladd. 58 recovered a mortality of 14 per cent. Twelve had other types of operations none recovered a mortality of 100 per cent. Gangrene of the bowel and other complications were factors in the mortality in these cases.

### MECKEL'S DIVERTICULUM

**Definition.**—The vitellointestinal duct is the communication between the mid gut and the yolk sac during the first few weeks of fetal life. Persistence of this duct or parts of it in postnatal life was first described by Meckel in 1815 since which time it has been known as Meckel's diverticulum. Meckel's diverticulum arises from the free or antimesenteric portion of the ileum about 20 inches above the ileocecal valve. The persistence of this duct is estimated to occur in from 2 to 4 per cent of infants.

**Pathology.**—Though a Meckel's diverticulum may be present throughout life without causing symptoms it is subject to a wide variety of pathologic changes and must always be considered a potential source of danger. (1) It may remain attached to the umbilicus with a patent opening or intestinal fistula. (2) it may remain attached to the umbilicus without a patent opening. (3) it may become detached from the umbilicus and hang loose in the abdominal cavity or its tip may become attached to some other point in the peritoneal cavity and cause intestinal obstruction. (4) it may

become the site of acute inflammation or diverticulitis. (5) in many instances it contains aberrant gastric mucosa and is prone to show ulceration with hemorrhage or perforation and (6) in some instances it inverts itself into the lumen of the ileum and acts as the advancing point of an intussusception.

**Symptoms.**—The symptoms caused by Meckel's diverticulum are variable according to the type of developmental error and the pathologic conditions arising from it. The patent opening at the umbilicus gives the inconvenience and annoyance of any fecal fistula with the difficulty of taking care of the fecal discharge and the irritation or digestion of the surrounding skin. The diverticulum which remains attached to the umbilicus may give intermittent abdominal pain of rather mild character referred to the umbilicus or more severe pain associated with vomiting, abdominal distention and visible peristalsis in short the signs and symptoms of intestinal obstruction. The diverticulum which is not attached to the umbilicus may become adherent to almost any point in the abdominal cavity across a loop of intestine and cause intestinal obstruction. When a Meckel's diverticulum is the site of acute inflammation the signs and symptoms are similar to those of acute appendicitis and this erroneous diagnosis is frequently made. The importance of hemorrhage from the bowel as a symptom of Meckel's diverticulum must be emphasized. It occurred in over 60 per cent of a series of cases reported by Hudson from the Children's Hospital of Boston and attention has been called to this important symptom by Mason and Graham and others. In instances in which the ulceration perforates the signs are those of peritonitis frequently preceded by a history of blood in the stools. If a Meckel's diverticulum is inverted into the lumen of the intestine causing intussusception the symptoms and signs are of course those of intussusception.

**Treatment.**—The treatment of Meckel's diverticulum is surgical and aimed at relieving the variety of conditions which it causes. Thus if peritonitis exists the peritoneal cavity should be drained if intestinal obstruction is present it must be relieved and when intussusception is found that must be reduced. All the operative procedures entail

removal of the Meckel's diverticulum. This should be done with a transverse incision in the ileum at the base of the diverticulum and the incision sewed up transversely so as not to obstruct the lumen of the ileum. There is always a temptation to remove a diverticulum as one would an appendix by a tie at its base and inversion of its stump with a purse string suture. This procedure should be condemned because of the probability that intestinal obstruction will result.

**Prognosis**—The results of operative relief of the conditions caused by Meckel's diverticulum have not been as satisfactory as they should be. Hudson reports 10 deaths in a series of 40 cases from the Children's Hospital of Boston. Recognition of the condition and earlier diagnosis with appropriate surgical relief should reduce this mortality appreciably.

#### DUPLICATIONS OF THE ALIMENTARY TRACT

**Definition, Etiology and Pathology**—The term duplications of the alimentary tract is used in the hope of simplifying the nomenclature and because it more accurately describes the condition found. Some of the terms that have been employed are mesenteric cyst, enteric cyst, enterogenous cyst, diverticulum, giant diverticulum, ileum duplex, jejunum duplex, and unusual Meckel's diverticulum. All these names are used to describe the same condition and none of them is as accurately descriptive as the term duplication. In the last fifteen years my colleagues and I have had twenty-six patients with duplications in various parts of the alimentary tract. The ileum is the most frequent place for duplication to occur but the condition has been found in the jejunum, duodenum, stomach, mediastinum and tongue.

Grossly the cysts are variable in size but quite uniform in structure. A section through the wall will show a serous layer, a muscular layer and a layer of mucous membrane as in the alimentary tract. The mucous membrane may be like that of the colon, the stomach, the duodenum or the ileum. The contents of the cyst may be mucoid fluid, sometimes chocolate colored and sometimes almost colorless. In some instances

the fluid is sterile but it may contain pus cells or colon bacilli. The chemical content of the fluid has been found similar to the succus entericus found in an isolated loop of bowel.

**Symptomatology**—The symptoms vary according to the size and the situation of the malformation. When the cyst is in the chest, it causes coughing, cyanosis or dyspnea. If it is in the abdomen, there is pain and symptoms of acute or chronic intestinal obstruction are evident. Hemorrhage from a peptic ulcer of the lining of the duplication may take place and may be sufficiently profuse to be alarming or fatal. Perforation with attendant peritonitis has also occurred. A correct preoperative diagnosis is seldom made. It may be difficult to differentiate between Meckel's diverticulum, intussusception, an omental cyst and intestinal obstruction resulting from other causes.

In all our cases in which duplication occurred in the abdomen, vomiting was a prominent symptom. Mild pain or abdominal discomfort was present in all and under nourishment or feeding difficulties were usually a part of the picture. Most of these patients had been treated as feeding problems.

The blood found in the stools may come from a peptic ulcer next to misplaced gastric mucosa in the lining of the duplication or from congestion of the intestine by pressure of the cyst. The tumor may usually be felt and is likely to be rather more mobile than tumors of other origin. Roentgen examination of the abdomen is sometimes helpful but often is not. In one instance it showed free air in the peritoneal cavity denoting perforation and in one instance it showed pressure on the stomach and on the colon. It may demonstrate partial obstruction which of course can be diagnosed by other means also.

From our experience duplication of the alimentary tract should be suspected in a child suffering from symptoms of partial intestinal obstruction in whom a freely movable tumor may be felt. It should be suspected also when blood is found in the stools when the symptoms are less acute than those of intussusception and when the tumor is larger than one would expect in a case of Meckel's diverticulum.

**Treatment**—The treatment of this condition is of course surgical and on account of the danger of obstruction perforation or hemorrhage the operation should not be unduly delayed. The operative technique is of importance and usually involves resection of the loop of the bowel to which the cyst is attached. It is a temptation for the surgeon who meets one of these cases for the first time to attempt to dissect the duplication away from the normal bowel. It is unwise to do this except in the rare case in which the duplication is detached from the normal bowel and has a mesentery of its own. In the usual case the blood supply of the duplication and the blood supply of the bowel to which it is attached are the same and if one dissects the duplication the blood supply of the bowel is destroyed. Another reason it is unwise or indeed impossible to dissect the duplication from the normal bowel is that there is no line of cleavage between the two. The partition between them consists of two layers of mucous membrane with the muscle layers between and it is almost impossible to separate them without perforating the lumen of one or both.

**Prognosis**—If operation is undertaken prior to the occurrence of infection perforation or severe hemorrhage the risk is not great and the results are gratifying.

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#### INJECTIONS AND TUMORS OF THE SMALL INTESTINE

The apparent freedom of the small bowel from disease is remarkable. It is seldom mal-formed and seldom the site of tumors. Its two outstanding infections, tuberculo and typhoid, are nowadays rare. Obstruction is the chief disorder to which it is subject. Apart from this, disturbances of its function are assumed to be infrequent at least their presence is seldom considered in the differential diagnosis of abdominal disease. It is possible however that dysfunction of the small bowel causes more trouble than has been ascribed to it. It would seem unlikely that an organ which performs so vital and complicated a function as digestion and absorption of food should be the seat of little or no trouble. There is reason to suspect that its disorders are often the cause of symptoms erroneously attributed to cholecystitis, chronic appendicitis, nervous indigestion, etc., and that grave disturbances of metabolism are caused by its failure to absorb vitamins or other essential substances from food. The recent literature shows a growing interest in this subject. The technique of roentgenologic examination of the small intestine has recently been greatly improved by the use of injections of contrast media through the Miller-Abbott tube. This permits demonstration of tumors and other lesions which heretofore could be discovered only at operation or autopsy. Roentgenologists can now recognize with ease a characteristic dysfunction of the small intestine due to lack of the vitamin B complex which may be noted with sprue, celiac disease or states of inadequate nutrition. Recognition of this condition is of great importance in the preparation of patients for operation and in the postoperative care of patients who are unable to take an adequate diet. The x-ray picture shows hypomotility of the small intestine with puddling of the barium content and irregular segmentation of it. Campbell has recently reviewed this subject.

#### NON SPECIFIC INFECTIONS

From the time the infant begins to take food the small intestine contains bacteria. The forms present are few in the nursing infant but become more numerous when a

general diet is taken. Years ago Harvey Cushing showed that in the fasting state the duodenum is practically sterile and that the number of bacteria increases from duodenum to ileocecal valve where it is very great. It is doubtful if the normal bacterial inhabitants of the human intestine aid digestion though bacteria in the intestines of her bivia do so by breaking down cellulose. Furthermore it is doubtful if bacteria in the human intestine do harm except when the bowel has been injured in some way. Injury to the bowel followed by infection may be caused by (1) debilitating systemic disease (2) achlorhydria gastrica or gastroenterostomy—conditions which cause too rapid emptying of the stomach (3) intestinal obstruction, which produces anemia of the bowel by overdistention or by interference with its mesenteric circulation and (4) parasites which penetrate the mucosa.

Normally the food passes through the small bowel so rapidly that it is difficult to believe that bacterial action in the intestinal contents can be very great until the food enters the large intestine. Some pediatricians have expressed the view that bacteria in the small bowel may produce a serious ascending infection of the duodenum and stomach of a child in whom achlorhydria has developed because of some systemic disease. It is possible that the diarrhea which often follows in a day or two the relief of an intestinal obstruction is due to an infection of the small bowel. Infection of the small bowel can cause diarrhea by interfering with the proper digestion and absorption of food, the result being that undigested food is poured into the large bowel.

Mesenteric lymphadenitis is best considered under the heading of non specific infections of the small bowel. The most common pathologic finding at laparotomy is enlargement of the mesenteric lymph glands. Hundreds of these ranging from the size of a large almond to that of a grain of wheat, sage like in appearance may be seen studying the entire mesentery of the small bowel. Mesenteric lymphadenitis is always associated with enlargement of the retroperitoneal glands. The writer in common with others has subjected great numbers of these glands to microscopic examination and has found almost always simple hyperplasia without

evidence of tuberculosis. Mesenteric lymphadenitis is most common in young patients but is not uncommon in patients of any age. It is most marked in the glands of the lower ileum. It is often the only evidence of intra abdominal disease found at exploratory laparotomy. It is noteworthy that no observable abnormality of the intestine usually accompanies it.

The etiology of non tuberculous mesenteric lymphadenitis is unknown. Infection of the intestine and the presence of intestinal parasites have been suggested as causes but no evidence of the presence of either can be found in the vast majority of cases. It is by no means certain that the lymphatic hyperplasia is due to infection at all. The glands have almost always been found to be sterile. It is possible that the most common cause is the absorption of incompletely or improperly digested protein material from the bowel. It is a common observation that injections of foreign proteins can cause enlargement of lymph glands. Infection however is the cause in some cases because suppuration of the glands has been observed. Certain authorities have attributed mesenteric lymphadenitis to appendicitis. The experience of the writer supports the idea that appendicitis is the most serious and most common complication of mesenteric lymphadenitis. If this is true then both would seem to be due to the same cause namely something which stimulates hyperplasia of the lymphoid tissue. There is a large quantity of lymphoid tissue in the submucous coat of the appendix. Hyperplasia of this tissue will block the lumen of the appendix thereby causing its distention and interference with its blood supply.

The clinical symptoms said to be associated with mesenteric lymphadenitis are (1) pain usually in the right iliac fossa (2) more or less generalized abdominal tenderness on pressure but without muscle spasm (the area of maximal tenderness is often in the right iliac fossa), (3) occasional fever, usually of from  $1^{\circ}$  to  $2^{\circ}$  F., (4) moderate leukocytosis (5) flatulence (6) dyspepsia (7) and general malaise and nervous instability. It is obvious that these symptoms are liable to be interpreted as due to appendicitis, nervous indigestion, hyperacidity, cholecystitis etc. The differential diagnosis from

subacute appendicitis cannot be made. The outlook is favorable. This subject is worthy of further clinical and experimental study.<sup>2</sup>

### SPECIFIC INFECTIONS

Under this heading are included (a) typhoid fever (b) tuberculosis and (c) regional ileitis.

Regional ileitis presents a definite pathologic picture but is of unknown etiology. The writer has been unable to find a report of primary actinomycosis of the small intestine. Syphilis occurs rarely in the jejunum of infants and also rarely at the ileocecal valve in adults. Asiatic cholera, bacillary dysentery and amebic dysentery (which may involve the terminal ileum) are not within the scope of this discussion.

Typhoid fever affects the lymphatic follicles of the intestine. For this reason the lesions occur chiefly in the ileum and are most numerous near the ileocecal valve. The follicles become swollen early in the course of the disease. The surgeon can easily recognize the presence of the enlarged Peyer's patches by the elevated and hyperemic areas they produce on the peritoneal surface of the bowel. They may undergo either resolution or necrosis and sloughing. In the latter case ulcers result which are ovoid or irregular in shape, having their long axes parallel to the long axis of the bowel and having the submucosa, the muscularis or even the peritoneum as a base. It is the sloughing of Peyer's patches which causes the surgical complications of typhoid fever—hemorrhage and perforation. Both occur at the time of separation of the sloughs, usually in the third week of the disease.

The diagnosis of perforation of the bowel due to typhoid fever depends chiefly on the occurrence of a sudden sharp abdominal pain, usually in the lower part of the abdomen and to the right of the midline. This is followed by tenderness on pressure and muscle spasm. The patient also shows signs of shock with an increase in the pulse rate and a drop in temperature. Vomiting may or may not be present. Later the signs of general peritonitis appear. This picture may be obscured or absent in a profoundly toxic patient. Perhaps the most important rule to observe in making the diagnosis is to *watch every patient with typhoid fever constantly*

*and carefully for suspicious abdominal symptoms.* Laboratory tests are of but little help. In doubtful cases it is safer to operate at once than to worry too long over the diagnosis. These patients endure operation remarkably well and laparotomy seems to exert a curative effect on the disease.

Typhoid fever has become so rare that the present generation of surgeons has had but little experience in treating its complications. At the Indiana University Hospitals from 1914 to 1934 in 76,518 admissions there were 222 cases of typhoid fever and 2 cases of perforation of the bowel due to typhoid fever.

Operation to be effective must be performed early. Either local or general anesthesia is used and a low short right rectum incision is made. All free intestinal contents are carefully removed by aspiration. The terminal ileum is explored for the perforation which will usually be found within a few feet of the ileocecal valve. If it is small it may be closed with fine silk. If it is large or if numerous ulcers on the point of perforation are found it is best to resect the entire piece of involved ileum and bring the ends of bowel out as a gun barrel enterostomy. Surgeons of the past generation emphasize the poor healing of wounds in typhoid patients. They observed that the wound would remain for days without showing any signs of granulation. It is known now that this trouble was due to avitaminosis and the starvation treatment. It should not occur in the patient treated according to modern methods.

*Intestinal hemorrhage in typhoid fever* is also due to sloughing of Peyer's patches and usually occurs in the third week. The symptoms are those of internal hemorrhage—rather sudden pallor, acceleration of the pulse rate, a fall in the temperature, restlessness followed by torpor and with large and sudden loss of blood, air hunger, sooner or later blood appears in the stools. The sudden pain characteristic of perforation is absent though it may be simulated by tetanus. Perforation may accompany hemorrhage. It should be mentioned that there will be no immediate change in the blood count or hemoglobin value.

*Treatment* consists of (1) withdrawal of all food by mouth, (2) intravenous admin-

istration of salt solution and glucose in quantities sufficient to meet the physiologic needs of the patient (it is doubtful if this will increase or reactivate the hemorrhage if care is used) and (3) blood transfusion if the loss of blood has been great. Morphine may be necessary to control restlessness but should be used with caution because of the danger of masking symptoms.

**Tuberculosis**—Tuberculosis may invade the walls of the small bowel from its peritoneal or from its mucosal surface. In tuberculous peritonitis the infection may penetrate to the lumen of the intestine or it may so weaken the bowel wall that it easily ruptures when adhesions are being freed at operation. When the infection attacks the mucosa it localizes as does typhoid fever in the lymph follicles. Unlike typhoid however it usually produces fibrosis of the surrounding tissues and of the lymphatic vessels draining the ulcers. Since these vessels encircle the bowel their contraction as a result of fibrosis causes a narrow constriction of the bowel as though a cord were tied around it. Multiple constrictions of this kind make the intestine resemble a string of sausages.

The diagnosis of the mucosal form of intestinal tuberculosis is easy to make if the condition complicates pulmonary tuberculosis. It sometimes occurs when pulmonary lesions are apparently inactive or absent. Fever, diarrhea with a little blood in the stools, loss of weight and in advanced cases signs of obstruction should lead to careful examination of the stools and roentgen examination of the intestine. In the absence of perforation or of obstruction the treatment is medical. Patients in whom obstruction develops have the disease in the dry or sclerotic form. Excellent results are obtained from resection of the involved portion of bowel.

**Regional Ileitis**—Crohn, Ginzburg and Oppenheimer<sup>3, 4</sup> in 1930 first called attention to regional ileitis as a clinical entity. They described it as a granulomatous inflammation of unknown etiology involving the terminal part of the ileum. It is characterized morphologically by thickening of the bowel wall by ulceration of the mucosa and in some cases by perforation of the bowel or the formation of fistulas into contiguous loops of intestine. Clinically it is

characterized in general by abdominal pain, fever, diarrhea, anorexia, loss of weight and strength and vomiting and sometimes by obstruction sometimes by peritonitis due to perforation and always by a chronic course. It is not always cured by resection of the involved segment of bowel. When it is complicated by fistula or obstruction a palliative operation should be done before resection is undertaken. Spontaneous cure occurs in some cases. Brown, Bagen and Weber report 18 cases of regional enteritis. They state that the disease may attack the jejunum, the ileum or the proximal portion of the colon. Though the literature on regional ileitis is now extensive the etiology is still unknown.

### TUMORS OF THE SMALL INTESTINE

A benign tumor of the small intestine is very rare but of rather numerous varieties. Lipoma, myoma, adenoma, adenomyoma, fibroma, angioma, pancreatic rests, cysts and various kinds of polypi have been observed. They may grow into the lumen of the bowel or outward beneath the peritoneum. They often start an intussusception. Certain of them, e. g., angioma and myoma may cause great loss of blood. Colicky pain seems to be the earliest symptom. Blood may be present in the stools. The physical findings are those of partial or complete intestinal obstruction. A palpable mass may or may not be present. Roentgen examination with a barium meal if obstruction is not complete or by means of a flat plate showing the intestinal gas patterns if it is complete is of value. The diagnosis has usually not been made before laparotomy performed to relieve obstruction. Treatment is of course resection of the portion of bowel containing the tumor.

B. Malignant tumors also are rare. They are of three kinds: (1) adenocarcinomas, (2) carcinosarcomas and (3) sarcomas.

1. **Adenocarcinoma** of the small intestine very seldom arises in polypi according to Fung. Its most common location is near the ampulla of Vater. There it causes jaundice, the pancreatic form of diarrhea, rapid emaciation and in some cases symptoms resembling those of pyloric obstruction. In the jejunum and ileum it causes progressive obstruction and anemia. Rankin and Mayo

report 55 cases observed at the Mayo Clinic. The youngest of the patients was thirty-two, the oldest sixty-nine. The average age was forty-seven and one-half years. Typical findings on physical examination were visible peristalsis, loud borborygmi and sometimes a palpable tumor. The roentgenographic study was a valuable aid to diagnosis. The results of resection were almost totally bad because of the early presence of metastases.

2. **Carcinoid** (see section on Ganglioneuromas) —The name carcinoid has been given to a remarkable tumor which may develop anywhere in the intestinal tract but is found most often in the appendix. Its next most frequent site is the small intestine. It has a distinctive and easily recognizable histologic appearance superficially resembling basal cell cancer. Its cells contain granules which reduce a solution of ammoniacal silver; hence they are called argentaffin. They stain with chromic acid and are therefore chromaffin. Their histogenesis has been the subject of much study and dispute and there is still no general agreement about it among authorities. An endodermal, a mesodermal and an ectodermal (neurogenic) origin have been attributed to them. The subject is too complicated and technical to be discussed here. Reference should be made to the paper by Cooke<sup>7</sup> for a complete presentation of the entire subject of carcinoid.

The following facts concerning the clinical features of carcinoid of the small bowel are of importance:

(1) The tumors are usually small, submucosal nodules, yellowish or grayish on section but they may be annular growths which obstruct the bowel. They are often multiple in origin.

(2) Their most common site is in the terminal ileum.

(3) About 20 per cent of carcinoids of the small bowel produce metastases in the lymph glands and liver. They are therefore liable to be more malignant than carcinoids of the appendix which do not metastasize beyond the regional lymph nodes.

(4) The average age incidence in the reported cases is about fifty-five years. The tumor is slightly more common in males.

(5) Though carcinoid is a rare tumor it should be considered as a possible cause of obstruction of the small bowel.

3. **Sarcoma** —Lymphosarcoma is the most common form of sarcoma of the small bowel though almost every known form of sarcoma has been found there. About 200 cases have been reported to date. It occurs at all ages of life having been observed in a child of three years. It is about twice as common in males as in females. It has no characteristic clinical picture though writers report certain fairly constant features, namely, intestinal disturbance, rapid loss of weight and rapid development of anemia. Its progress is usually more rapid than that of cancer of the bowel. Lymphosarcoma is liable to cause obstruction because its growth is usually less fibrotic and less liable to involve the entire circumference of the bowel. It is more liable to cause perforation of the bowel than is cancer. It is said to be less liable to cause intestinal hemorrhage. Metastasis is of course more widespread and earlier than in cancer. The tumor is likely to become fixed to surrounding structures by adhesions.

The diagnosis has probably never been made with certainty before operation or autopsy. A careful roentgen study of the small bowel may reveal the presence of some form of tumor of the bowel and a careful consideration of all the clinical data may lead to a diagnosis of sarcoma.

The prognosis of sarcoma of the intestine depends on the histologic character of the tumor. Cure of fibrosarcoma has been reported. Unfortunately the outlook for the form usually found, lymphosarcoma, is almost hopeless though roentgen therapy may give good immediate results.

The treatment is resection of the involved piece of bowel and of a wide area of mesentery followed after operation by deep roentgen therapy.

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## APPENDICITIS

**Definition.**—Acute appendicitis is essentially a bacterial infection involving the appendix a part or the whole of which may be affected. Appendicitis is common. There are however certain nomadic tribes in which the disease is rare. The restraints placed on the proper exercise of bowel function in civilized life may account for its greater frequency among certain peoples. The symptoms of appendicitis are usually well defined and clearcut but there are cases that are not easily diagnosed. The commonness of the disease should offer an incentive to every physician to possess thorough knowledge of it. If he approaches each suspected case of appendicitis with the purpose not merely of making a diagnosis but also of committing himself to a prediction as to the location and exact pathologic condition of the appendix, appendicitis will prove to be a disease of unending interest.

**Historical.**—Appendicitis should have been recognized as a clinical entity long before 1886 when Reginald Fitz of Boston recognized it and aroused the profession to take an active interest in it. A century ago attention had been drawn to the fact that inflammation occurs in the appendix. Meivier in 1759 is credited with being the first to publish such an observation. In 1812 Parkinson attributed a case of fatal peritonitis to a perforated appendix. Twelve years later Lousier & Hermain described a case of gangrenous appendicitis in which there was no competent inflammation of the cecum. A careful thought-out paper was presented in 1857 by Meier based on 5 cases and he emphasized the probable frequency of the condition. Meier is believed to have been the first to recognize a case of appendicitis during life. Unfortunately his conclusions were rejected by the great authorities of the day. Dupuytren. This famous surgeon attributed abscesses and peritonitis arising in the right side of the abdomen to inflammation of the cecum which he called pentopylitis. Krönlein in 1884 was the first surgeon to recognize a case of peritonitis due to perforation of the appendix and to remove this organ.

**Anatomy.**—The length of the vermiform appendix may vary from 3 to 20 cm and the thickness from 3 to 15 mm. But far more important is a realization that this structure may be in any one of nine different positions. These are in their order of relative frequency: (1) into the pelvis (2) along the iliac vessels (3) to the promontory of the sacrum (4) posterior to the cecum (5) under the ileum (6) lateral to the cecum (7) into the iliac fossa (8) among the coils of small intestine and (9) medial to the cecum (Fig 554).

**Incidence.**—Acute infection of the appendix may occur at any age. The earliest case reported was in an infant three days old. The author has operated on an appendiceal abscess in a patient who was in the nineties. It is however in the second and third decades of life that the disease occurs most frequently and it is generally agreed that men are affected somewhat more often than women. Likewise there is unanimity of opinion regarding the relative frequency of appendicitis among highly civilized and primitive peoples. The latter group seldom suffer from this ailment as long as they are untrammelled by the restrictions of civilization. It seems clear that dietary habits lack of physical exercise and modes of living which restrict the natural tendencies to frequent and complete defecation favor the incidence of appendicitis. Thus it follows that cases are more common in an urban population than in a rural one. Similarly they are seen more often among European Turks who eat meat in large amounts than among Asiatic Turks who subsist on bulkier food. Likewise troops who engaged in actual field maneuvers were found to have a low incidence of appendicitis whereas the same group of soldiers while confined to the sedentary life of a cantonment had a high incidence. In the Orient the disease is astonishingly infrequent and the author ventures to suggest that the posture assumed by Orientals when defecating accounts for this fact. In the East natives squat when defecating. This posture forcefully flexes the thighs on the abdomen and thus tends to empty the cecum completely. There are no accurate data to show that real appendicitis is more frequent among wealthy persons than among the poorer classes. The question has been





infected material from the cecum into the appendix. This belief is supported by pathologic studies of appendices removed shortly after the onset of symptoms for in such cases the lesion is invariably found in the interior of the organ with no evidence of infection on the peritoneal side. Aschoff believes that the actual site of the beginning of the inflammatory process is in the depressions and pits of the mucous membrane where mechanical factors are conducive to the growth and penetration of bacteria. There must of course be a small break in the mucous membrane which is covered quickly by a bit of fibrin and leukocytes. The inflammatory reaction spreads in a wedge-shaped manner from this focus and may subside or may progress to the formation of an intramural abscess. Such an abscess in turn may resolve or may rupture either into the lumen causing ulceration or into the peritoneal cavity. Whether there are cases in which the passage of bacteria through the mucous membrane depends on lowered vitality (resistance) of the patient rather than on trauma of the mucous membrane seems improbable since clinically one does not see the disease occurring more frequently in patients who are sickly than in people who are in vigorous health. Another etiological factor is a change in the type or in the virulence of the bacteria lodging in the lumen of the appendix for in many cases there is no localized site of inflammatory reaction but a widespread diffuse involvement of the entire mucous membrane. The lining of the lumen is fiery red and swollen. This is the lesion one is likely to see when appendicitis comes on as an extension of acute colitis.

In some cases an enterolith is unmistakably an etiological factor. These concretions are either balls of inspissated mucus, bacteria and cellular debris or particles of fecal matter covered over with mucus. Fecal matter as such is seldom seen in a normal appendix as this structure is constantly secreting mucus and actively discharging it into the cecum. Authorities disagree as to the actual role which enteroliths play in the causation of appendicitis not infrequently at autopsy a normal appendix is seen to contain this concretion. On the other hand it is exceedingly common at operation to find the

lumen of an appendix occluded by a large enterolith and distal to this the tissues engorged and infected whereas proximally they are normal. Enteroliths frequently cause pressure necrosis with resultant ulceration and perforation. One statistical study reports the occurrence of such destructive lesions in 85 per cent of the cases with enteroliths. Aschoff however has recorded an unusual instance in which the entire appendix was gangrenous except the area beneath a large enterolith.

An important etiological factor is stenosis or occlusion of the lumen of the appendix. This may be due to a scar resulting from a previous infection to congenital peritoneal bands to postinflammatory peritoneal adhesions or to sharp kinking of the appendix. Whenever complete occlusion of the lumen occurs one is likely to find a distended distal portion. Frequently there is little or no active infection and one has the feeling that the condition is simply a mechanical one.

**Bacteriology.**—The bacteriology of acute appendicitis is not clearcut and distinct. Cultures of a variety of pathogenic organisms have been made from the areas of infection. Only cultures made at the time of operation and carefully worked up are of any significance for colon bacilli quickly overgrow other bacteria. It is not surprising therefore to learn that in nearly all the early studies on this subject the colon bacillus was assigned the predominating role as etiologic agent. More recent work has emphasized the significance of streptococci. Hum considers these organisms as the most frequent infecting agents of acute appendicitis. He obtained streptococci in pure culture in 16 of 23 cases. Oberndorfer holds the same opinion. Whether or not colon bacilli alone can cause severe infection in the appendix is an important problem that has not yet been solved. Whenever streptococci are solely responsible for acute appendicitis one finds thin scanty odorless pus whereas in those cases that are due to a mixed infection or to colon infection there is thick foul smelling pus. There are moreover other differences due to the prevailing bacteria. Mixed infections tend to quick invasion and early gangrene streptococcal infections are said to occur predominantly in young patients while colon infections are seen usually in elderly ones.

an indispensable feature of appendicitis. Actually one finds tenderness and spasm at McBurney's point only when the appendix happens to lie beneath it. Absence of this sign therefore does not minimize in the slightest the chance that a case is one of appendicitis. Whenever an acutely inflamed appendix is in actual contact with the peritoneum of the anterior abdominal wall there is extreme tenderness and rigidity of the overlying muscles. When the offending organ extends into the pelvis there may be no muscle spasm and the only point of tenderness is that detected on making a pelvic or rectal examination. When the appendix lies retroceally the maximum tenderness and muscular rigidity are posterior but seldom as far up as the costovertebral angle.

**Temperature and Pulse Rate**—There is nothing characteristic about the temperature curve in this disease unless it is that high fever at the onset ( $103^{\circ}\text{F}$ ) makes the diagnosis improbable. Absence of fever does not vitiate the diagnosis. Ordinarily it is wise to take the temperature by rectum in cases of appendicitis and it is usually found to be slightly above normal. The temperature tends to rise with the progress of the infection but there is no constant or reliable relationship. The duration of fever also varies and may be from one to several days. More important and constant are accelerations in the pulse rate. Unfortunately few patients know their normal pulse rate and unless this is established it is impossible to detect an increase of 20 or 30 beats a minute. A pulse rate of more than 110 in cases of appendicitis is very suggestive that perforation has occurred. It is most exceptional for appendicitis to begin with chill and when this symptom does occur one suspects the presence of a grave complication such as pyelophlebitis. Occasionally a severe chill results when an inflamed appendix lies in apposition to the right ureter or the iliac vessels.

**Gastrointestinal Symptoms**—Nausea and vomiting frequently thought to be integral parts of the syndrome of appendicitis are as a matter of fact incidental and are often entirely absent. One can safely say that nausea and vomiting rarely if ever are the presenting symptoms of this disease. In some cases however severe nausea and protracted vomiting occur after the onset of abdominal

pain. A more constant symptom of appendicitis is a disinclination to eat. Seldom does a patient with an acute condition of the appendix care to eat a hearty meal. Moreover when food is taken there is often an increase in the severity of the cramps in the right lower quadrant. It was formerly said that constipation is always associated with this ailment but it is more correct to say that constipation or diarrhea or both are usually associated with it. Treves carefully questioned 48 patients and reports constipation in 26, diarrhea in 13, normal movements in only 8 and constipation alternating with diarrhea in 1. The cases beginning with severe diarrhea and generalized abdominal cramps are particularly treacherous for in these cases the evidences of appendicitis do not appear until after from twelve to thirty six hours. It seems likely that these are cases of colitis in which involvement of the appendix is secondary.

**Leukocytosis**—There is a growing tendency to disregard the white cell count in cases of appendicitis. A safe point of view is to regard a leukocyte count of 10,000 to 20,000 as confirmatory evidence of the disease. A differential count with an increase in the number of polymorphonuclear cells especially an increased percentage of immature forms is a trifle more suggestive. It must be remembered however that one never waits for leukocytosis before making the diagnosis of appendicitis. There are thousands of patients with acute appendicitis who have had a normal white cell count. In fact the severest infections which produce early gangrene and rapidly progressive peritonitis frequently cause no leukocytosis whatsoever.

**Differential Diagnosis**—*Renal and Ureteral Calculi*—Sometimes the differentiation between renal or ureteral colic and appendicitis is far from easy particularly when the inflamed appendix lies along the ureter and consequently causes the appearance of red blood cells and pus cells in the urine. The pain associated with the passage of renal and ureteral calculi tends to become maximal shortly after the beginning of an attack and continues with great severity whereas the pain of appendicitis is more intermittent owing to peristalsis and seldom begins in an excruciating manner. Furthermore in renal

colic the pain is often out of proportion to other signs and symptoms. The characteristic radiation of ureteral pain to the bladder and genitalia is often a conclusive factor in making the diagnosis. With appendicitis there is nearly always more muscle spasm than in cases of ureteral colic. Whenever there is associated pyelitis with ureteral disease it is possible to elicit the telltale tenderness in the costovertebral angle. A roentgenogram will usually determine the presence of a stone although calcifications in glands are sometimes confusing.

*Intermittent hydronephrosis* is of interest because it is not often kept in mind and because the clinical picture can simulate that of appendicitis. The pain from hydronephrosis usually reaches its maximum intensity soon and remains there. If there is radiation it is into the groin but often the pain is dull and persistent and is localized in the flank. If an enlarged kidney is palpable or if the patient suddenly passes a large quantity of urine with disappearance of the pain the diagnosis is easy. In cases of uncertainty a pyelogram is usually conclusive.

*Pyelitis*—In this condition there is generally but not always pus in the urine. It must be remembered that an acutely inflamed appendix lying in contact with a ureter may cause pus cells to appear in the urine. The fever in pyelitis usually is higher and there may be lumbar tenderness and dysuria. Chills frequently result from pyelitis rarely from appendicitis.

*Disease of the gallbladder* is one of the most important ailments to differentiate from appendicitis. The difficulty lies in the fact that often lesions in the gallbladder do not give rise to the classical radiation of pain through the body to the tip of the right scapula. Furthermore when the liver is low or the gallbladder enlarged one may find localized tenderness at McBurney's point and vice versa a long appendix especially if it is retrocecal may give rise to pain and tenderness in the right upper quadrant. Occasionally the tip of the appendix will reach as far upward as the gallbladder. A most helpful clue in recognizing disease of the gallbladder is the history of many previous attacks. Another aid is the story of a similar attack of severe pain which entirely disappeared in a few hours. True appendi-

citis does not subside with the abruptness of gallbladder colic. In general gallbladder colic is more abrupt in its onset more severe in intensity and of shorter duration than the pain of appendicitis.

*Acute Salpingitis*—In a community with a large colored population and a consequently high incidence of salpingitis acute salpingitis is the most frequent and often the most difficult condition to differentiate from appendicitis. These patients often give an unreliable history of the onset of their sickness. To add to the difficulty both conditions give rise to varying degrees of fever, leukocytosis and gastrointestinal symptoms. Bilateral tenderness on pelvic examination is the most reliable differential point. The presence of a profuse vaginal discharge is helpful but not conclusive. In many cases it is impossible to be certain whether one is dealing with an abscess arising from the tubes or from an appendix lying over the pelvic brim.

*Perforation of a Duodenal Ulcer*—An uncomplicated duodenal ulcer rarely causes any confusion with acute appendicitis but it sometimes happens that following perforation of such an ulcer the duodenal contents gravitate along the outer side of the colon and collect in the right iliac fossa. Several hours after perforation tenderness, muscle spasm and a mass may be found over the appendix. An accurate history in these cases usually indicates the correct diagnosis.

*Ovarian and Uterine Conditions*—The pain produced by the strangulation of the pedicle of an ovarian cyst or uterine fibroid may be like that of appendicitis but is usually more abrupt in onset, persists without exacerbations and is often associated with moderate shock. Localized tenderness and rigidity are nearly always present and may interfere with palpation of the tumor. A fairly frequent condition that sometimes reproduces the syndrome of appendicitis is that due to rupture of a cyst of a graafian follicle. This occurs ordinarily about two weeks after menstruation and causes cramp-like pain, fever and leukocytosis. A similar picture may occur with rupture of a corpus luteum at or near the time of menstruation. Gastrointestinal symptoms, localized abdominal tenderness and rigidity are usually absent.

There are a large number of other diseases that may produce a clinical picture which can be mistaken for that of appendicitis. Some forms of tuberculous peritonitis can give the signs and symptoms of an appendiceal abscess. Diaphragmatic pleurisy and even pneumonia particularly in children can be exceedingly difficult to differentiate from intra abdominal conditions. The character and rate of respiration physical findings and roentgen examination of the chest will be helpful in these cases. Patients with illnesses due to typhoid and paratyphoid organisms are sometimes erroneously operated on for appendicitis. In these cases however the degree of fever the bradycardia and the leukopenia are of some diagnostic value. Acute lymphadenitis frequently gives signs and symptoms identical with those of acute appendicitis. The presence of preceding inguinal adenitis or of injury to the skin overlying the right lower extremity arouses a suspicion of this condition. Acute lymphadenitis is particularly likely to occur in children. Incomplete intestinal obstruction ruptured ectopic pregnancy subacute pancreatitis and abscess of the abdominal wall are occasionally mistaken for appendicitis. An acutely inflamed Meckel's diverticulum gives the identical signs and symptoms of appendicitis and should be looked for at operation whenever the appendix does not show pathologic changes that are in keeping with the clinical picture.

**Complications—Abscess.**—There are no complications of acute appendicitis as long as the infection is within the appendix but once the organisms reach the peritoneal surface serious and far reaching complications may develop. The commonest of these is the development of an abscess about the appendix. Naturally the evidences of such an abscess depend on the position of the appendix. The most frequent site is between the cecum and the anterior abdominal wall. Such abscesses often reach considerable size and cause a visible fullness in the right lower quadrant. Occasionally if the tip of an inflamed appendix extends to the midline an abscess forms on the left side of the abdomen being directed there by the root of the mesentery. Not infrequently an appendix reaching into the pelvis gives rise to an abscess that is indistinguishable from a tubo-ovarian abscess

and can be detected only on rectal or vaginal examination. When a retrocecal appendix forms an abscess the pus may rupture spontaneously into the ascending colon but is more likely to extend upward and lead to the formation of a subphrenic abscess. Occasionally an abscess forms as a postoperative complication and makes itself known by continued fever of a more or less hectic type.

**Peritonitis.**—Whether or not a patient has the ability to wall off a perforated or gangrenous appendix depends on factors that are not clearly understood. It seems however that hyperperistalsis induced by erythrasis frequently prevents localization and leads to diffuse peritonitis. Clinically one suspects this complication from the patient's pulse rate and from the widespread abdominal tenderness. The latter sign appears earlier and is more constant than rigidity of the entire abdominal wall. Soon however the hippocratic facies and abdominal distention make the diagnosis obvious. In patients with peritonitis paralytic ileus often develops which is evidenced by great distention obstipation vomiting of large quantities of black fluid and signs of circulatory collapse. Many patients with peritonitis recover following removal of the appendix and drainage of the abdominal cavity. Few patients with well developed paralytic ileus recover.

**Peritoneal Adhesions.**—A late and often very serious complication of appendicitis is intestinal obstruction due to postinflammatory or postoperative adhesions. The more extensive the infectious process the greater the probability of adhesions.

**Subphrenic Abscess.**—Whenever there is perforation of the appendix but particularly when this structure lies retrocecally the infection may extend upward and localize in the right subphrenic space. Persistent high fever septic in type is often the first clue to the existence of such an abscess. The physical signs of such a condition are sometimes difficult to demonstrate and it frequently happens that a roentgenogram which shows a high diaphragm on the right side is earlier confirmatory evidence than the physical examination. At times the roentgenogram will show gas between the liver and the diaphragm. In any case of doubt aspiration of pus should be attempted (See section on Subphrenic Abscess).

**Suppurative Thrombosis of the Portal Vein (Pylephlebitis)**—One cannot be certain how often this complication develops, for probably some patients recover without operative treatment. Whenever a patient with appendicitis or during convalescence after appendectomy has a chill and fever, one suspects suppurative pylephlebitis. The writer has observed a case in which symptoms developed twenty-four hours after removal of a gangrenous appendix. In another instance the patient had a severe chill at the beginning of the fourth recurrence and subsequently died of pylephlebitis. Usually

monary infarct, and hemorrhage or purulent effusion follows, depending on the number and variety of bacteria present.

**Treatment.**—There is only one treatment for acute appendicitis—to operate as soon as the diagnosis is made, for the symptoms do not always accurately indicate the character or extent of the infectious process. It must be remembered that perforation can occur within a few hours after the initial symptoms, and the most virulent infections progress the most rapidly. To delay operation is to invite unjustifiable complications and death. It is unpardonable to give opiates

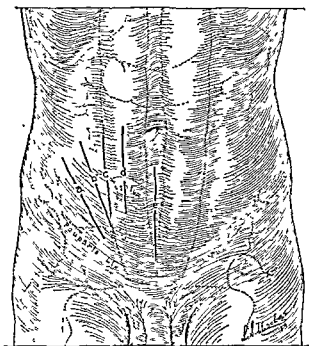


Fig. 555.—Incisions commonly used for appendectomy: a, McBurney; b, Fowler; c, Lennander; d, Battle; e, median incision used particularly for the exploration of the pelvis in conjunction with appendectomy.

the liver becomes enlarged, and chills and fever persist. Jaundice or at least a subicteric tint is seen. Aspiration of the liver at operation often fails to reveal pus, because of the occurrence of milary abscesses rather than a single large one.

**Pulmonary embolism** is an occasional complication of appendicitis. The emboli result from thrombosis of the veins of Retzius or of those in the pelvis or extremities. In some cases the infected appendix is adjacent to the vein, and this position accounts for the thrombosis. Smaller emboli make themselves known by pleural pain and bloody expectoration. A friction rub develops over the pul-

monary cathartics in an illness that is even suspected of being appendicitis. If, as occasionally happens, immediate operation is impossible, then absolute rest of the body and of the gastrointestinal tract (starvation and morphia) and cold applications to the right lower quadrant offer the best chances for subsidence or localization of the infection. The choice of anesthesia, the type of incision and the postoperative care are details for each surgeon to decide for himself.

When a patient is seen after an attack has spontaneously subsided (so-called "interval appendicitis"), it is good judgment to advise removal of the appendix. In some cases when

the patient is not seen by a physician until the third or fourth day of the illness it is debatable whether or not an immediate operation should be performed since at that time operative intervention may break through a partially localized infection and lead to peritonitis.

**Operations.**—When describing the operative treatment of appendicitis it is necessary to discuss separately the handling of

conditions and the operations are planned so as to afford access to the organ without weakening the abdominal wall. Naturally any operation that is done as often as appendectomy is will have required a variety of technical modifications many of which are of no particular merit. A simple and popular method of appendectomy is the following.

A diagonal incision is made in the right lower quadrant (Fig. 555). The level and

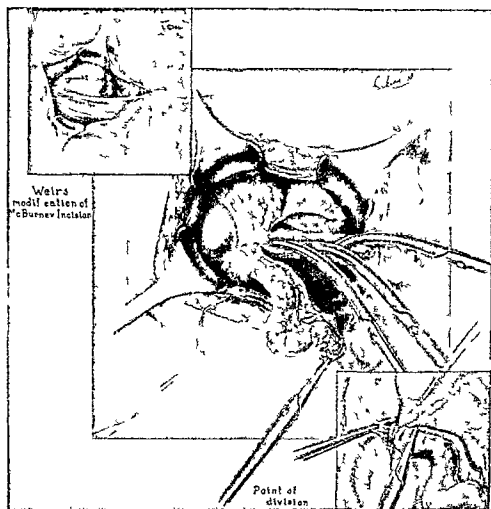


Fig. 556—Exposure of the cecum and appendix through a McBurney incision and the initial steps in an appendectomy.

ruptured and unruptured appendices. For the sake of clearness it is advisable to consider the subject under three headings: simple appendicitis, the perforated appendix with localized peritonitis or abscess, and acute appendicitis with diffuse peritonitis.

The first group includes all cases in which the inflammatory process, whether recent or old, is confined to the appendix. The removal of this structure is carried out under aseptic

conditions. The length of this incision varies according to the position of the appendix and the thickness of the abdominal wall. The incision is carried down to the fascia of the external oblique muscle, which is incised parallel to the direction of its fibers. Similarly, the muscle bundles of the internal oblique and of the transversalis are separated parallel to their course. No muscle fibers are cut across. By gentle traction the opening in the mus-

cles is enlarged. The peritoneum underlying the transversalis is then loosened by digital dissection so that it bulges into the wound. The peritoneal cavity is carefully opened and the cecum and appendix are brought up into the wound (Fig 556). The mesoappendix bearing the appendicular artery is clamped, divided and ligated. A purse-string suture is placed about the base of the appendix and the surrounding tissues are covered with gauze pads. A peritoneal cuff is reflected near the base of the appendix which is then crushed, ligated, clamped and divided (Fig 556). The stump of the appendix is sterilized with tincture of iodine; the gauze pads are removed and the stump is carefully inverted into the cecum (Fig 557). The purse-string suture is drawn taut and tied (Fig 557). Any raw areas in the mesoappendix are turned in and the closure of the

adhesions the operator must divide these structures carefully. In many such cases it is necessary to deliver the appendix by beginning the dissection of the mesoappendix at the cecum and continuing out toward the tip of the appendix.

The convalescent care of a patient who has had a simple appendectomy through a muscle splitting incision presents few if any problems. The degree of nausea and postoperative discomfort is determined more by the anesthesia than by the operation. The duration of recumbency depends on the routine of the surgeon but it is customary for these patients to remain in bed for two or three days.

If a patient is seen after the infection has spread beyond the appendix but has been limited to surrounding tissues the surgeon is confronted with a difficult problem. If ap-



Fig 55 —Final steps in an appendectomy

abdominal wound is commenced by approximating the edges of the peritoneum with a continuous suture. The separated bundles of the transversalis and internal oblique muscles need little or no suturing inasmuch as every contraction of these muscles tends to bring the fibers together. The fascia of the external oblique is carefully reapproximated and the skin is closed.

In some cases a McBurney incision such as has been described does not provide adequate exposure. It is helpful then to extend the incision of the fascia of the external oblique muscle medially to the border of the rectus and to divide the sheath of this muscle so as to retract the muscle without incising it. Such a procedure is called the Weir modification of a McBurney incision (Fig 556). In those cases in which the cecum and appendix cannot be brought up because of

pendectomy is performed immediately there is the risk of breaking through the newly formed adhesions and thus causing spreading peritonitis. If the appendix is not removed the infection in it may fail to subside and may serve as the source of a serious peritonitis. No hard and fast rule can be given regarding the course to follow in such cases for there is no unanimity of opinion among surgeons. The decision to operate immediately or to postpone operation rests with the surgeon and not the attending physician. When the latter course is pursued the patient should be kept in bed and should frequently be given sedatives and nothing by mouth. Fluids can be administered per rectum or intravenously. When an abscess has formed and localization of the infection has existed for four or five days it is safe to drain the abscess and to remove the rem-



nants of the appendix. The incision that is used in such cases again depends on the judgment of the surgeon. A few urge the use of a rectus incision for an appendiceal abscess inasmuch as the incidence of postoperative hernia is considerably less when the abscess is drained through such an incision than when it is drained through a McBurney incision. Most surgeons however contend that the opening of an appendiceal abscess through a right rectus incision favors the dissemination of pus through the peritoneal cavity. (See the important comment on treatment of abscesses in the section on Peritonitis.)

The actual removal of the appendix in the presence of an abscess is carried out in the simplest manner. It is not always expedient to try to invert the stump into the thickened and inflamed cecum. The drainage of the abscess must be adequate but it is important to remember that the primary purpose of drains is to establish a tract through which pus can reach the surface; consequently in a case of appendiceal abscess it is wise to allow the drains to remain in place for seven or eight days by which time they are likely to be extruded spontaneously.

Obviously the most serious cases of appendicitis are those associated with wide spread infection of the peritoneal cavity. In treating such cases the primary objective is to remove the source of the infection that is to say the gangrenous or perforated appendix. The surgeon should bend every effort to do this quickly and with as little trauma as possible to the abdominal viscera. The second purpose is to provide drainage of the peritoneal cavity particularly in the locations where pus is likely to accumulate and form abscesses; therefore cigarette drains are placed beside or posterior to the cecum into the pelvis and toward the ileocecal mesentery. In some cases it is necessary to place additional drains through a small wound on the left side of the abdomen.

The advent of sulfonamide therapy has greatly altered the treatment and the prognosis of ruptured appendicitis. There are some surgeons who go so far as to place 6 to 8 Gm. of sulfanilamide crystals in the peritoneal cavity and close it without drainage. It is true that most surgeons have stopped

placing the drains deeply in the cavity and are content to drain the wound down to the peritoneum. It seems clear that the deposition of more than 10 Gm. of a sulfonamide is contraindicated inasmuch as the portal blood levels may rise as high as 60 mg. per hundred cubic centimeters when greater quantities are given.

After operation the patient with peritonitis should be kept in Fowler's position. Every effort must be made to relieve distention which all too frequently is the precursor of fatal adynamic ileus. Change of posture, gastric large duodenal drainage, frequent enemas with turpentine, use of stupes, complete abstinence from food and fluids by mouth, administration of chlorides intravenously and adequate rest at night all aid in the accomplishment of this result. Attempted stimulation of the paralyzed intestine by the use of drugs is futile. Operative procedures such as jejunostomy or ileostomy are contraindicated inasmuch as they fail to empty more than a few inches of intestine.

**Prognosis.**—The prognosis in cases of acute appendicitis depends on the promptness with which the diagnosis is made and operation performed. Miles and his co-workers point out in their analysis of 910 cases of acute appendicitis that the mortality for a group of patients operated on in the first twenty-four hours of the disease was 2.7 per cent against a mortality of 6.5 per cent for patients in whom the duration of the illness was more than twenty-four hours. If the inflamed appendix is removed before perforation or gangrene has occurred the outlook for recovery is excellent. The deaths that occur following simple appendectomy without drainage of the peritoneal cavity are due to the anesthetic or to embolism and are exceedingly rare. The gravity of a case is increased a hundredfold if complicated by perforation or gangrene since either of these conditions can cause generalized peritonitis which inevitably results in death in a certain number of cases. When the infection reaches the peritoneum the prognosis is seriously altered for although there is walling off and localization of the infection death sometimes follows. Some observers think that operations performed just after natural walling off has occurred do more harm than good.

## CHRONIC APPENDICITIS

It is unfortunate that this term has been used in medical circles for there has never been any agreement as to what constitutes the clinical picture resulting from so called chronic appendicitis and moreover there is no such pathologic entity. The term has been used loosely and often serves to mask the physician's ignorance of the real nature of a patient's ailment. One does see how ever changes in the vermiform appendix after an acute inflammatory process. These changes have been described in the preceding section and as pointed out they pre dispose to recurring infections. The term chronic recurring appendicitis is more in keeping with the facts and connotes the tendency to the recurrence of acute attacks. The pathologic alterations resulting from acute inflammation of the appendix may give rise to indefinite symptoms often referred to some other organ such as the stomach or intestines. Many times the patient is unable to describe the symptoms accurately or to give them an exact location. There may be anorexia eructations a sense of fullness after eating and tenderness in the epigastrium. In other cases the symptoms are referred to the lower abdomen. The patients complain of tenderness often diffuse but at times over the cecum. There may be borborygmus constipation and indigestion. An aggravation of these symptoms is sometimes noticed after exercises such as bending lifting or stretching. The indefiniteness of the syndrome makes the diagnosis uncertain but the history of an initial attack is suggestive. It is significant that appendectomy relieves the symptoms in only about half of the cases in which a diagnosis of chronic appendicitis is made.

WARFIELD M. FIOR

## INTESTINAL OBSTRUCTION

## GENERAL FEATURES OF INTESTINAL OBSTRUCTION

*(Occlusion of the Bowel, Intestinal Stasis Ileus)*

**Definition.**—In the broad sense any interference with progression of the intestinal current constitutes obstruction of the intestine. This conception embraces interference

with intestinal continuity from whatever cause and includes those of inhibitive (paralytic) as well as those of mechanical origin. In the more restricted interpretation of common usage however the term intestinal obstruction is often employed to denote obstructions of mechanical origin alone.

**Etiology.**—By far the larger number of instances of intestinal obstruction are caused by mechanical agents such as (1) narrowing of the lumen due to strictures of the intestinal wall (2) obturation of its lumen by a foreign body or compression of the lumen from without (3) adhesions (4) hernia (5) volvulus (6) intussusception and (7) embryologic defects such as apertures in the mesentery, abnormal fixation as well as failure of rotation of the gut and Meckel's diverticulum. Upsets in the nervous mechanism interfere with intestinal motility these may be inhibitive (paralytic) or spastic in nature. Finally interruption of the normal blood flow to or from the intestinal tract such as embolism or thrombosis of the mesenteric vessels or severance of vessels by trauma will effectually obstruct the onward motion of the intestinal content.

Strictures which obstruct the intestinal tract may be congenital or acquired inflammatory or neoplastic. They may occur in either the large or the small intestine. Atresia of a segment of the small intestine and imperforation of the anal canal and rectum constitute the congenital stenoses which cause intestinal obstruction. Carcinoma in the sigmoid flexure of the colon and diverticulitis are the commonest instances of acquired stricture giving rise to occlusion of the bowel. In addition benign tumors such as lipomas fibromas polyps or hemangiomas and malignant tumors such as carcinomas carcinoid tumors as well as sarcomas may occur in either the small or the large bowel and obstruct its continuity by encroachment on the lumen.

Obstruction of the intestine by compression from without is likely to occur only where the tract is fixed as in the pelvis or the retroperitoneal duodenum and less frequently in the terminal ileum.

Adhesions and hernia are generally the most frequently observed causes of intestinal obstruction. Oddly enough however geographic location seems to affect the in

cidence considerably. In England, Australia and Denmark, intussusception constitutes one of the most frequently observed types of intestinal obstruction. Reports from Russia and Serbia indicate that volvulus is responsible for more than 50 per cent of all cases of obstruction observed, whereas, generally, it accounts for less than 10 per cent in most series.

As has been indicated, the main types of obstruction from the standpoint of causative factors are mechanical, nervous and vascular. A satisfactory classification for both clinician and pathologist may be made by correlating, with the commonly observed varieties of obstruction, the factors of etiology and pathologic appearance as indicated in the accompanying table (Table 13)

TABLE 13—COMBINED CLINICAL AND PATHOLOGIC CLASSIFICATION AND TREATMENT OF TYPES OF INTESTINAL OBSTRUCTION

Clinical classification	Pathologic classification	Treatment
<b>I MECHANICAL OBSTRUCTION</b> <b>A</b> Narrowing of lumen <b>1</b> Strictures of intestinal wall a Congenital { atresia imperforate anus inflammatory b Acquired { traumatic vascular neoplastic <b>2</b> Obturation <b>3</b> Compression from without (especially pelvis and retroperitoneal duode- num)	Simple (except in neoplastic strictures of the colon)	Operation preceded by suc- tion for decompression in late cases except in occlu- sion of the colon
<b>B</b> Intestinal obstruction due to adhesions and bands { congenital inflammatory traumatic neoplastic	Simple or strangulation	Suction operation for per- sistent obstruction and in strangulation
<b>C</b> Hernia <b>1</b> External <b>2</b> Internal <b>D</b> Volvulus <b>E</b> Intussusception <b>F</b> Developmental errors which give rise to in- testinal obstruction (other than congen- ital stenosis)	Strangulation	Early operation
<b>II INTSTINAL OBSTRUCTION DUE TO          NERVOUS IMBALANCE</b> <b>A</b> Inhibition (paralytic) ileus <b>B</b> Spastic or dynamic obstruction	Simple	Suction
<b>III VASCULAR OBSTRUCTION</b> <b>A</b> Intestinal obstruction due to mesenteric thrombosis and embolism	Strangulation	Early operation

**Pathologic Considerations.**—*Classification*—From the point of view of a pathologic division, there are essentially two types of intestinal obstruction, viz., simple and *strangulating obstruction*. In the former are included all cases in which blockage of the continuity of the bowel exists, in strangulation there is in addition evidence of compromise of the blood supply.

**Morbid Anatomy.**—In simple obstruction the bowel above the obstructing mechanism is distended and in obstruction of an acute nature the wall is thinned out in chronic obstructions the intestinal wall is thickened largely as a result of hypertrophy of the circular muscle. The intestine in acute obstruction is as a rule somewhat redder than usual owing to hyperemia of its wall. The distention is due to the accumulation of fluid and gas proximal to the obstruction. The length of the intestine concerned in the distention is dependent on the duration of the obstruction. The

degree of distention is determined largely by whether the obstruction is partial or complete. High grade distention usually accompanies total occlusion occasionally the intestinal wall weeps and a serous fluid may be present in the peritoneal cavity. The intestine distal to the obstruction is usually empty and contracted. The only commonly observed obstruction of a simple nature which frequently exhibits the pathologic features of strangulation is a stricture of the colon; the reason for which will be discussed presently.

Though there is a possibility for serious interference with the flow of blood through the agency of increase in intraluminal tension, actually the anatomical effects of such an influence are apparent only in the obstruction of closed loops. These may be established experimentally by inverting both ends of a segment of intestine; clinically they must be observed in cases of obstruction of the colon in which the competent proximal ileocolic sphincter makes this simple obstruction a virtual closed loop in which the effects of a markedly increased intraluminal tension become evident: ulceration, gangrene and perforation.

Direct measurements of the tension within the bowel have been made by the writer at operation. Despite enormous distention of the small intestine, pressures of the order of magnitude of from 4 to 16 cm. of water have been recorded. The participation of long segments of bowel in the distention precludes the occurrence of a high sustained pressure. In colonic obstruction, however, great increase of the intraluminal tension is usually found; pressures of from 20 to 30 cm. of water having been observed.

All the signs of tissue death may be observed in the intestinal wall in obstruction of a strangulating character. The wall varies in color from that of a dusky cyanosis to a bluish black. This discoloration is occasioned by hemorrhagic infarction of the wall consequent on arrest of return of the venous blood from the intestine. In addition the lumen may be filled with blood and there is often a serosanguineous transudate in the peritoneal cavity. The loss of blood may be great when the strangulated segment is long. The arrest of the flow of blood concerns largely prevention of egress of blood from the bowel since blood continues to be pumped into the intestine under the motive force of systolic blood pressure; leaks in the veins occur and considerable blood may be lost. When the intraluminal tension becomes great enough to compromise the capillary circulation of the intestine, anemic necrosis and gangrene or perforation may occur.

The return of normal color to the bowel wall and contractile responses on pinching it together with normal pulsations in the mesenteric vessels determine after the intestine has been released from the strangulating mechanism whether the intestine is still viable.

The bowel above the strangulated segment exhibits the various changes previously described under simple obstruction.

**Physiologic Considerations**—Hartwell and Hoguet found that dogs that were given saline solution subcutaneously survived for a considerable time obstruction of the upper intestine which otherwise proved fatal in a few days. This finding has been corroborated by a number of experimental workers in the field. It was first believed that the saline solution detoxified

a toxin X and acted as an antidote for the poison absorbed. It was later demonstrated that after temporary administration the saline solution could be discontinued and the dogs lived about as long. After having been temporarily fortified in this manner against loss of fluid from the upper reaches of the alimentary canal by vomiting, the dogs apparently accommodated themselves to this dehydration process.

High intestinal obstruction or complete duodenal fistula (in which fluids are similarly lost) in dogs causes the development of characteristic changes in the chemistry of the blood: decrease of the chlorides, increase in the alkali reserve and elevation of the non-protein nitrogen content. If saline solution is administered these changes do not occur.

If the obstruction is located in the lower portion of the ileum or in the colon these changes are rarely observed, probably because the electrolytes, largely sodium and chloride ions which are seriously depleted in obstruction of the upper bowel are afforded an opportunity for at least partial absorption in low obstructions. The administration of saline solution to dogs with ileal and colonic obstruction does not prolong their lives as it does in high jejunal obstructions. Saline solution exhibits the virtues of a specific in these high occlusions, therefore, because it serves as an adequate substitute for the fluids lost by vomiting. Other fluids or different combinations of sodium and chloride radicals will not ward off early death in such animals.

There are three possible sources of the gas in the distended bowel. By far the greater portion is (1) swallowed air (70 per cent); the remainder is to be accounted for as a result of (2) local putrefaction and fermentation and (3) a portion is brought to the bowel by an interchange from the blood stream. Since the swallowed air is largely nitrogen (80 per cent), it is not readily absorbed. Carbon dioxide which largely results from fermentation is readily absorbed under ordinary conditions but not when the bowel is distended. Ammonia, methane, hydrogen and hydrogen sulfide products of putrefaction are not readily absorbed.

The fluid component of the distention comes largely from the digestive secretions. Under conditions of obstruction, however, the secretion from the intestine itself seems to be enhanced, an irritative phenomenon as a result of the dilatation of the bowel wall apparently and in part due to the increased osmotic pressure of the bowel fluids occasioned by lack of normal absorption.

The cause of death in strangulation obstruction in which the loss of blood may be great and death of tissue occurs is not difficult of interpretation. In simple obstruction on the contrary apart from the high obstructions which have just been described and which incidentally are rarely observed clinically, the cause of death is still unknown.

It has been predicated that an abnormal toxin not unlike histamine forms in the bowel; the absorption of which brings on the sequence of consequences which lead to a lethal issue. The injection of fairly large quantities of histamine into such a segment, however, appears to be well borne.

Continued distention of long segments of bowel which cannot be emptied adequately by vomiting results in sustained increases of intraluminal tension and

occurrence which opens up a new avenue of absorption viz transperitoneal migration of noxious toxins and bacteria, through the injured bowel wall. Without question this is the most serious consequence attending unrelieved simple obstruction. Increased intraluminal tension interferes with venous outflow from the bowel wall. Increases in venous pressures are reflected directly by similar increases in capillary hydrostatic pressure. In consequence there is increased capillary filtration with increased edema of the bowel wall which owing to increasing distention is at the same time becoming thinner also. Anoxia of the bowel wall with impaired vascularity and increased capillary permeability is a natural result.

Intestinal distention may be attended by increases in the venous pressure in the lower extremities and by slowing of the circulation time as determined by the sodium cyanide method (Bell's and Wangensteen 1939). That loss of blood is an important item in strangulating obstructions was pointed out by Scott and Wangensteen in 1939. This observation has been confirmed by a number of investigators. Fine and his associates have described diminution in plasma volume in simple obstruction (1940).

**Symptoms**—The chief complaints of patients with intestinal obstruction are of pain and vomiting and later when the obstruction has become well established distention. The pain is intermittent and crampy and is usually described by the patient as a gas pain. The cramp is usually not long in duration; it rises in crescendo fashion and quickly reaches its peak and after being sustained in its maximum severity for a variable length of time usually one to three minutes abruptly ceases. A plateau type of pain curve is practically never observed. Occasionally, as noted not infrequently in intussusception, the pain may be somewhat rhythmic in its occurrence. This colicky distress may recur frequently or at long intervals depending on the nature of the obstruction. Late in the course of obstruction when the intestine has become considerably dilated and the optimal contractile diameter of the intestine has been exceeded the colic is less severe.

Whereas reflex vomiting may occur in any acute abdominal disorder, the significance of mechanical block in determining the character of the vomitus becomes apparent in intestinal occlusion. When high grade occlusion of the small intestine occurs incident to the accumulation of fluid and gas above the site of obstruction, the vomiting is frequent and copious. There is only one variety of obstruction of the bowel in which the distention may be great and yet no vomiting

occurs viz obstruction of the colon. The rapidly formed distention apart from the reflex vomiting which may occur initially has no bearing on this peculiarity. This circumstance attests only the importance of the regurgitant feature in the vomiting of bowel occlusion. In obstruction of the colon the proximal ileocecal valve and sphincter are usually competent and behave like a check valve permitting gas and fluid to come into the colon from the ileum without regurgitation into the ileum. In this the usual situation the distention remains limited to the colon and the small intestine does not participate in it frequently despite enormous distention there may be no vomiting.

**Physical Findings—General**—The appearance of the patient early in the course of obstruction often affords no evidence that he is suffering from a potentially serious ailment. The pulse rate, respirations, temperature and blood pressure are usually normal. Apart from the pain of which he complains, the vomiting and the distention he may not appear to be particularly ill. Late in obstruction owing to dehydration and other changes in bodily economy not wholly understood an anxious expression with sunken features, a feeble pulse and cold and livid extremities are noted.

In strangulating obstructions especially if the segment is long to which the blood supply is compromised the pulse may be hurried if the blood loss is great the symptoms of shock may be present. Owing to the irritation of the parietal peritoneum by the sanguineous fluid which escapes into the peritoneal cavity the patient suffers more distress than the patient with simple obstruction.

**Abdominal Findings**—When the patient is first seen there is usually moderate distention. In a chronic obstruction visible peristalsis is almost invariably present; the outline of the intestine may be observed on the abdominal wall and the peristaltic rushes felt with the hand. In an acute obstruction of short duration however peristalsis is not visible unless the abdominal wall is abnormally thin. Visible peristalsis is synonymous with hypertrophy of the circular muscle of the intestine and necessitates the elapsing of perhaps at least a week for its develop-

ment The diaphragmatic component of respiration is not ablated as often occurs in perforation of the upper reaches of the intestinal canal In simple obstruction the abdominal wall usually remains soft and no evidence of tenderness or rigidity of the abdominal muscles is present Occasionally but not often during the acme of the pain there may be slight tightening of the abdominal muscles which relax completely again when the pain is gone In strangulating obstruction on the contrary blood or hemorrhagic fluid escapes into the peritoneal cavity and gives rise to peritoneal irritation \* If an infarcted segment of intestine is present it may be felt as a mass through the abdominal wall or by digital examination of the rectum and vagina In simple obstruction when the distention is great in consequence of which the intestine may weep slight rebound tenderness may be present The degree of rigidity of the abdominal muscles however rarely becomes great If considerable fluid escapes into the peritoneum there may be pain in the shoulder due to irritation of the diaphragmatic peritoneum If the distention is great tympany will be marked Were it not for the gas in the intestine and the air in the lungs both would be as dull as the liver on percussion

The most significant findings are obtained on auscultation If a patient suffers from a block in the intestinal continuity borborygmi may be heard at the height of the intermittent pain of which he complains The concomitant occurrence of borborygmi at the acme of the pain establishes the presence of *intestinal colic* It then only remains to be determined whether the *intestinal colic* is that of bowel obstruction food indiscretion allergy or enterocolitis These intestinal sounds are usually gurgling bubbling noises much like those produced by pouring water out of an inverted bottle with a narrow neck

\* The parietal peritoneum is the most sensitive of all the serous membranes The degree of peritoneal irritation present is usually predicated on the character of the irritant The most pronounced rigidity of the abdomen is observed attending the perforation of a duodenal or gastric ulcer into the free peritoneal cavity with escape of hydrochloric acid pancreatic juice and bile Perforation of the rectum may be accompanied by abdominal pain which is scarcely appreciable for feces through a source of danger to the peritoneum, is not a severe irritant.

If the bowel is under considerable tension the noise has a metallic character Whereas such sounds may be heard with the stethoscope over the abdomen under a number of varying circumstances unless the noises are due to *intestinal colic* there is no intimate time relationship between pain and borborygmi

**Laboratory Data—General**—In consequence of the dehydration concentration of the blood occurs and increased values for hemoglobin red cells and leukocytes may be obtained Rebound abdominal tenderness associated with a mounting leukocyte count frequently portends the presence of a strangulating obstruction The urine is usually scant and albumin or casts may be present The urinary function is not impaired however for the liberal administration of saline solution corrects the oliguria and the abnormal findings disappear

The alterations in the blood chemistry previously described under Physiologic Considerations are of no diagnostic value in determining the presence of intestinal obstruction except in atypical instances Decrease in the blood chlorides increased combining power of the blood for carbon dioxide and elevation of the non protein nitrogen content are observed with regularity only in high obstructions and then only after forty eight hours

**Röntgen Examination**—Valuable evidence is obtained by roentgen examination in the diagnosis of intestinal obstruction Only rarely is the administration of an opaque medium permissible A single large scout film of the abdomen taken with the patient lying supine indicates the degree of intestinal distention present and determines where the distended coils are located A film taken with the patient sitting or erect shows gas mirrored over fluid but the configuration of the distended coils and the degree of distention are not apparent The scout film is consequently far more informative The exact location of the probable site of obstruction as determined by the distended intestinal loops is not as accurate for the small intestine as for the colon On the whole however it may usually be said whether the distention concerns the upper middle or lower third of the small intestine Gas is present throughout the gastrointestinal

canal, but normally in the adult it is visualized on the roentgen film only in the stomach and colon. In infants and children until about three years of age, gas may be seen throughout the intestine. The rapidity of transit through the small intestine is such that gas and fluid are so intimately intermixed as to preclude their demonstration on a roentgenogram. In the stomach and colon, where food and intestinal content remain for considerably longer periods, gas and fluid separate out. If intestinal stasis occurs in the small intestine from any cause, fluid and gas separate, and gas may be visualized on the roentgen film.



Fig 558—Enormous distention of the small intestine in a patient with intestinal colic. There was no gas in the colon, and no rebound tenderness. Therefore there was a complete simple obstruction of the lower ileum. (Enterostomy was performed; the patient has had no obstructive symptoms in the eleven years since then.)

It is immediately apparent that the roentgen findings must be correlated with the clinical observations. Whether the stasis is mechanical or inhibitive (paralytic) in origin, one may not be able to tell from an inspection of the roentgen films alone. To be certain, usually in inhibitive (paralytic) ileus, the entire intestinal tract is distended, whereas, in mechanical obstructions the distention concerns only the portion above the site of the occlusion even though there may be some gas in the colon beyond the obstruction. The stethoscope gives a dependable verdict.

*Is the Obstruction Complete or Incomplete?*—The chief source of gas in the intes-

tine is swallowed air. In mechanical obstructions it is a good plan to administer a soap and water enema which is expelled prior to taking the roentgenogram. If the gas persists in the colon after this it is probable that it has leaked past the obstructive mechanism and that the obstruction is incomplete. Absence of gas in the colon on such a film after evacuation of the colon by enemas indicates that the obstruction is complete (Fig. 558). When the presence of an inflammatory lesion in the peritoneal cavity is suspected and, particularly when appendicitis is a diagnostic possibility, the administration of an enema, either for pur-



Fig 559—Gaseous distention limited to the colon in a patient with intestinal colic. There had been no vomiting or gastric retention. There was an annular carcinoma in the sigmoid flexure of the pelvic colon.

poses of diagnosis or in the attempt to secure expulsion of gas, is contraindicated.

**Factors Contributing to Delay in Diagnosis of Obstruction.**—*Absence of Local Physical Findings.*—Lack of appreciation of the fact that simple obstruction of the bowel does not give rise to local physical findings, viz., tenderness and rigidity, often results in the impression that only a trivial condition is present. When it is remembered, however, that simple obstruction of the bowel is the only serious acute lesion which does not give rise to abdominal tenderness, a lack of local physical findings in a patient with abdominal pain, nausea and vomiting should make one suspicious of the presence of intestinal obstruction.

**Mistrust in Enemas**—It is frequently said that total obstipation characterizes intestinal obstruction. The bowel distal to the point of obstruction is physiologically as well as anatomically normal. In incomplete obstruction therefore gas may continue to be evacuated as long as enemas are administered. Only in complete low obstruction is total obstipation certain. The expulsion of gas and feces with an administered enema does not militate against the presence of obstruction.

**Abuse of Morphine**—The administration of morphine before the diagnosis is established assures the pain and lulls both patient and physician into a sense of false security. *Intestinal colic*, the pathognomonic sign of intestinal obstruction, is abolished. Morphine does not paralyze intestinal contractions; on the contrary it enhances the tone of the normal as well as the obstructed portion of the tract. The significance of the intestinal borborygmi which are to be heard on auscultation of the abdomen cannot be properly evaluated when pain is abated.

**Deception of Apparently Effectual Catharsis in Partial Obstructions**—The expulsion of a stool after the administration of a cathartic does not mean that the bowel is not obstructed and continuance of the pain indicates that the obstruction is still present. The employment of cathartics in mechanical obstruction is not to be recommended like morphine; they are a dangerous expedient.

**Differential Diagnosis**—The first essential in the diagnosis of obstruction is to establish the absence or presence of *intestinal colic*. Occlusion of the bowel is not caused by conditions which fail to produce it. In simple obstruction in which local physical findings are absent, enterocolitis, dietary indiscretions and allergy must be excluded. On the basis of the history of the complaint, the presence or absence of diarrhea and the nature of the constitutional symptoms, the differential diagnosis is usually readily made.

In strangulating obstructions accompanied by abdominal tenderness and rigidity, a large number of possibilities must be excluded. Here too the absence or presence of *intestinal colic* is the chief determinant. Occasionally in lesions such as strangulation of an ovarian cyst, a ruptured appendix or pelvic

inflammation, obstruction of the intestinal tract by the mass exudate or fibrinous adhesions may concomitantly obstruct the bowel and give rise to *intestinal colic*. In such instances at times it may be difficult or impossible to determine whether strangulating obstruction with the formation of a mass and the development of tenderness and rigidity of the abdominal wall was the primary condition or whether a simple obstruction was superimposed on one of the aforementioned conditions.

**Identification of the Type of Obstruction Present**—The exact nature of an obstruction is an item concerning which information is largely inferential and not absolute. External hernias, the congenital obstructions such as intestinal atresias and imperforations of the rectum and anal canal and intussusception of infancy may usually be accurately identified by the rather obvious findings or characteristic train of symptoms. *Obstruction of the colon is due usually to carcinoma* and less frequently to diverticulitis. *Spastic functional obstruction of the colon can usually be recognized by the occurrence of findings to be described under that caption*. The greatest difficulty is the determination of the exact nature of an obstruction in the small intestine. When external hernia and intussusception which statistically are rather common types of obstruction are excluded, adhesive obstruction is by all odds the most likely. Yet obstruction of the small bowel by a gallstone, carcinoma or an enteric intussusception though uncommon, occurs sufficiently frequently to demand attention in the consideration of the probable nature of an obstruction of the small intestine.

**Prognosis**—Whereas the mortality in acute intestinal obstruction has been unaccountably high (40 to 60 per cent), the more general early recognition and the employment of more rational procedures have resulted in definite improvement. In such obstructions as congenital atresia, strangulating obstruction, inhibitive (paralytic) ileus due to peritonitis and mesenteric thrombosis, the risk will always be great because of the obvious seriousness of these conditions. Early diagnosis and the judicious choice of well executed therapeutic procedures should be accompanied by a low mortality in most



types of obstruction. Though there are a number of potential strangulating obstructions, the time element figures prominently in all of them. The single variety of obstruction in which the blood supply is actually not available to the bowel is embolism or thrombosis of the mesenteric vessels. Release of the constricting agent in all other strangulating obstructions before the anat-

mechanical obstruction submitted to operation, the procedure of election may be carried out, viz., finding and determining the exact nature of the obstruction followed by accomplishment of its release. In late simple obstructions, release of the obstruction may be associated with an unnecessary hazard, and experience has shown that mere decompression of the intestine is safer. When

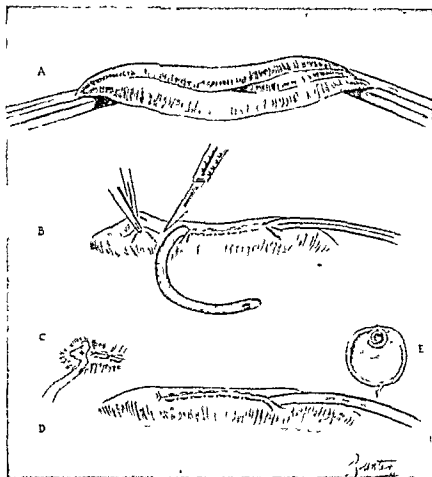


Fig 500—Technic of enterostomy. A, Contraction of a distended bowel upon evacuation of its content. This occurs immediately, and the bowel wall thickens surprisingly. B, A No 14 French catheter is laid upon the bowel and a few interrupted Halsted mattress sutures of fine silk make a tunnel for the catheter. Care must be taken to avoid spillage in puncturing the bowel. C, Employment of the 3-2 stitch to close the corner after introduction of the catheter into the bowel. D, Completion of the inversion. E, The resultant peritoneal tunnel. Withdrawal of the catheter, when enterostomy is made in this manner, is not followed by fistula.\*

mic changes consequent on prolonged interference with the blood supply of the segment have occurred obviates the necessity of dealing with a non-viable bowel. This is one of the most fundamental considerations in the treatment of all intestinal obstructions.

**Treatment.**—The ideal objective in mechanical occlusion is release or removal of the obstructing agent. In instances of early

the blood supply of the intestine is compromised by strangulation, freeing the gut of the obstructive mechanism is invariably mandatory, no matter how ill the patient may be.

In general it may be said that the agents of demonstrated value in the relief of ob-

\*Wangenstein, Intestinal Obstructions, Charles C Thomas Publisher

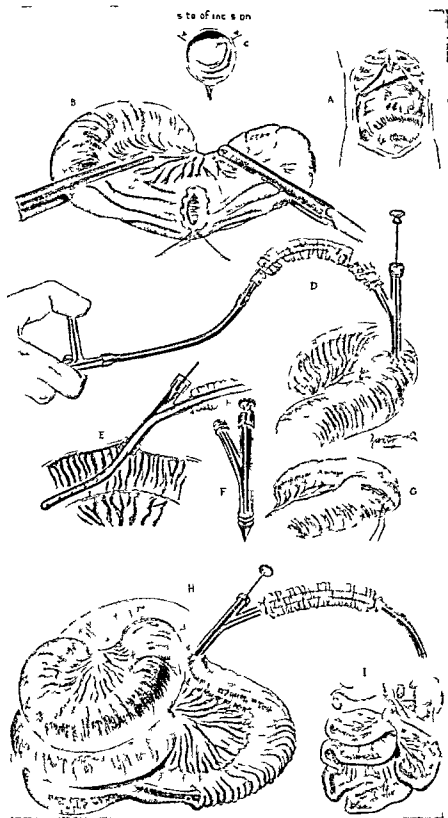


Fig. 561.—Technic of a safe decompressive suction enterotomy. *A* Distended intestinal coils. *B* An intestinal loop near the conjectured site of obstruction is delivered and segregated between rubber-covered intestinal clamps after being stripped. A purse-string suture is placed and an incision transverse to its axis is made in the bowel wall down to the mucosa. *C* The length of the incision. *D* The trochar is thrust into the bowel and the purse-string suture is tied. *A* T-tube with the skin held vertically permits the operator to make and

struction are (1) eradication of the obstructing mechanism by operation (2) decompression of the distended intestine (enterostomy or colostomy) or circumventing the obstruction by enteronastomosis, (3) decompression of the distended intestine by suction applied to an intlying duodenal tube (4) administration of saline solution and (5) blood and plasma transfusions

In parietic conditions of the intestinal tract agents such as hypertonic saline solution administered intravenously (Hughson and Scarff 1924) spinal anesthesia and drugs which enhance the contractile activity of the bowel (Ochsner, Gage and Cutting 1930) as well as enemas have a place. On the whole, however, their effect is transient, and decompression by suction applied to tubes introduced into the upper and the lower reaches of the intestinal tract constitutes a far more rational attack on the distention.

*Operation*—There are essentially two types of operative procedure employed in the treatment of intestinal obstruction. 1. A direct attack is made on the obstructive mechanism with establishment of the intestinal continuity. Occasionally this may be achieved by the reverse of an adhesive band, sometimes it necessitates the excision of a segment of the intestine (intestinal resection) together with the obstructing agent. This may be done in one stage (primary resection) or in two stages in which exteriorization of the offending segment is first done followed by subsequent anastomosis of the exteriorized loops of intestine by suture. Now and then it may appear wiser to make an initial enteroanastomosis around the obstructing agent to be followed later by its excision. 2. The indirect attack consists in merely establishing an external vent for drainage of the distended intestine in any segment of dilated intestine proximal to the point of obstruction. In obstruction of

the small bowel in accord with laws of good plumbing the drainage (*enterostomy*) should be fairly close to the point of obstruction in the colon the site of establishment of the external vent (*colostomy*) may depend on whether one wishes total or incomplete deviation of the fecal stream as well as on whether a subsequent operative attack may make it desirable to place the opening rather remotely from the site of the obstruction. Incomplete deviation of the fecal current in the colon may be achieved by appendicostomy, cecostomy or simple drainage through a tube. Complete deviation is to be achieved only by bringing a segment of the colon up on the abdominal wall.

In the performance of enterostomy or colostomy, it is essential that there be absolutely *no spillage*. An *aseptic* drainage must be established. Whereas in the unobstructed bowel slight contamination or soiling is usually inconsequential the occurrence of the most minute spillage in drainage of the obstructed intestine because of the multiplication of bacteria is synonymous with death from peritonitis. In addition to the establishment of aseptic drainage of the intestine it is important in obstructions of the small bowel to perform the enterostomy in such a manner that the vent will spontaneously close when the tube comes away (Fig. 560).

*Determination of the Viability of the Intestine*—If the bowel has a purplish discoloration it is immediately apparent that it is strangulated. If after release of the constriction the normal color returns to the bowel and pulsation to its vessels and the wall contracts on mechanical stimulation the bowel is viable, if the wall remains discolored after it has been left in a warm saline pack for a few minutes it is devitalized and should be excised. Under ordinary circumstances it is safer to establish the intestinal continuity after initial exteriorization of the

break the suction if the intestinal mucosa exhibits a tendency to cling to the perforations in the tube. The trochar accommodates a no. 20 F long rectal tube. The Penrose drain with glycerin within it facilitates manipulation of the rectal tube and prevents soiling or spillage. E The trochar in operation in a section of view. The small perforations in the catheter preclude injury to the bowel during suction. F The intestinal trochar. G Closure of the enterotomy opening with interrupted Halsted mattress sutures of fine silk after the obstructive agency has been dealt with. H Intestinal evacuation is effected by mild suction applied to the intestinal trochar. I The volumetric reduction effected by intestinal evacuation affords an opportunity of determining the nature of the obstructing mechanism.\*

segment than by primary resection. All anastomotic operations in the presence of intestinal obstruction carry a high risk for the patient.

**Decompression by Suction Siphonage Through Inlying Duodenal Catheter**—Most instances of incomplete simple mechanical obstruction of the small intestine may be safely treated by suction applied to an inlying duodenal tube. Similarly, lesser grades of colonic obstruction may be decompressed by aspirating the gas and fluid at the gateway of the intestinal canal which contribute largely to an augmentation of the distention. Experience indicates that a number of instances of mechanical obstruction of adhesive origin may be satisfactorily treated by this means without operative intervention. Just as enterostomy usually permits automatic establishment of the continuity of the intestine after drainage, so decompression by suction applied to a duodenal tube frequently accomplishes an adequate release from the obstructing mechanism. The advantage which enterostomy presents over suction applied to a duodenal catheter is that the bowel above the site of enterostomy may be used as a nutritive tube until the continuity of the tract is established. The Miller Abbott balloon-tipped tube which may after entry into the duodenum pass readily down the distended intestine has increased somewhat the likelihood of decompression in suitable cases through the agency of an indwelling tube. Subsequent operation for removal of the adhesive constricting agent is usually not necessary whether the decompression is achieved by means of enterostomy or by the duodenal tube. Should subsequent seizures of *intestinal colic* recur, however, an operative attack on the offending agent should be performed.

In inhibitive (paralytic) types of ileus, suction applied to an inlying duodenal as well as rectal tube is of great value. Of course, the prophylactic prevention of distention on the whole is more efficacious than treatment of established distention. When distention is to be anticipated following certain types of abdominal surgery, as operations on the biliary ducts and the stomach, the early employment of suction is of greatest value in obviating the occurrence of distention.

**Contraindications**—Attempts at obtaining decompression by this means are not to be attempted in strangulating obstructions or in acute obstructions of the colon with enormous distention in which the ileocolic valve and sphincter limit the distention to the large intestine. Operative intervention is indicated in such instances.

**Limitations of Conservative Decompression**—It is the interspersion of segments containing collections of gas and fluid that renders suction ineffectual. If the entire stomach and small intestine were distended with either fluid or gas alone, the exertion of 75 cm. of water suction (about the optimal degree of negative pressure) applied to a duodenal tube engaged in the upper reaches of the bowel would immediately empty out the entire intestinal canal, and this grade of negative pressure would be appreciated in almost the same degree at the cecum. With the possibility of doing away with the accretion of distention by continuous aspiration of swallowed air and constant removal of the fluids from the upper reaches of the intestine as they enter the intestinal canal from the stomach, liver and pancreas, with the confluence of gaseous and of fluid increments owing to changes in posture of the patient, the contractions of the intestine and absorption of fluid from the bowel, the existing distention is favorably influenced. The use of the Miller Abbott type of duodenal tube with an inflatable balloon at the tip has set aside some of these difficulties. For once this tube has entered the duodenum, its transit down the bowel is usually fairly rapid.

In cases of mechanical obstruction it is necessary to follow the decompression with roentgenograms every twelve or twenty-four hours to note whether the caliber of the distended intestine is becoming smaller, because usually the pain stops when suction is commenced, also the bowel accommodates itself to a certain grade of distention and ceases to cause painful contractions if the existing distention is not augmented.

Rectal suction for colonic decompression because of the presence of feces is not as efficacious as suction applied through an inlying duodenal tube. Irrigation alternated with suction proves more satisfactory (tidal irrigation).

## Saline Solution and Fluid Administration

—The greatest value of saline solution lies in its power to combat dehydration. Most clinical obstructions are low in the physiologic sense hence no specific virtue is to be expected of saline solution such as may be observed in experimental high obstruction or in a patient who has in obstruction at the

intelligent orientation concerning the salt requirements. Similarly, a careful hemoglobin determination together with ascertainment of the specific gravity of the plasma will indicate the degree of hemoconcentration or of dehydration that may be present.

Enough fluid should be given to maintain

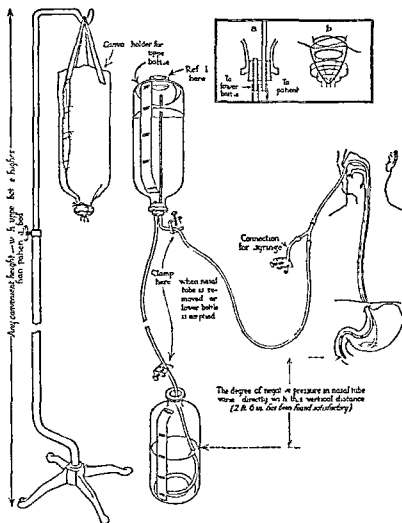


Fig. 56.—Diagram of suction apparatus employed in the treatment of intestinal obstruction. An effort should always be made to have the end of the catheter reach beyond the duodenum. Precautions are made so that suction may be exerted simultaneously on the stomach and on the duodenum. When the fluid aspirations are great a third bottle should be used as a collecting receptacle.

stoma after gastrojejunostomy or gastric resection.

In instances in which vomiting has been profuse one may expect reasonably that dehydration and dechlorination will have to be treated. Coller and his associates (1938) have formulated practical rules for the administration of salt and fluid under such circumstances. Plasma chloride determinations should be made as a matter of routine for

and daily urinary output of 700 to 1000 cc per twenty-four hours. Daily determination of the sodium chloride excretion in the urine together with periodic determination of the plasma chlorides will suffice to indicate the daily requirements of sodium chloride that must be met.

In addition to meeting the fluid electrolyte and vitamin (especially B and C)

• Warzenstein and Lane JAMA 110

requirements it is becoming increasingly evident that maintenance of caloric and nitrogen equilibrium in surgical patients is of the greatest importance. In patients with obstruction of the gastric outlet or intestinal canal the caloric and nitrogen balance can be maintained by intravenous feeding alone for short periods of time (two to three weeks). The slow intravenous infusion of 20 per cent glucose solution through a 22 gauge needle in the forearm or leg allows the administration of about 300 Gm (1500 cc of 20 per cent solution) over a ten to

ried pulse with other signs of impending or actual shock. Instances of volvulus intussusception strangulated hernias and torsion of the intestine due to adhesions represent instances in which the possibility of a serious loss of blood may be great. In all such instances adequate replacement of the loss by transfusion should be carried out before operation is undertaken. More and more the value of plasma in treating blood loss as well as blood volume reductions through loss of plasma is being universally recognized.

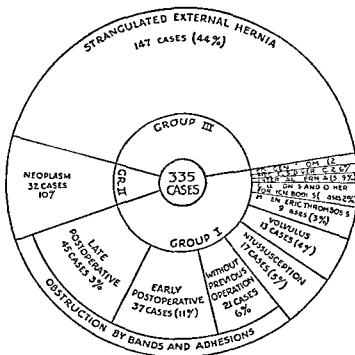


Fig 563—Incidence of various types of obstruction in a ten year period at the Massachusetts General Hospital during which time there were 39,936 surgical admissions.\* In the writer's experience adhesions constitute the most frequent cause of obstruction.

twelve hour period without great inconvenience to the patient and without much spillage of sugar in the urine. Daily quantitative determinations of the sugar lost in the urine are important to determine and regulate the rate of infusion. Amino acids and a complete protein such as plasma will sustain the nitrogen equilibrium on intravenous injection.

**Transfusion**—In all cases of strangulating obstruction there is some loss of blood into the infarcted tract. If the segment is long loss may be great as is indicated in a hur-

**Oxygen**—Inhalation of high concentrations of oxygen (Fine and his associates 1936) may facilitate diminution of intestinal distention by lowering the nitrogen tension in the plasma thus encouraging the slowly diffusible nitrogen in the lumen of the bowel to be given up for excretion through the lungs. There appears to be some hazard, however if high concentrations of oxygen in excess of 80 per cent are given over long periods of time without interruption (J R Payne 1941).

\*McIver Arch Surg 25

**BRIEF CONSIDERATION OF THE VARIOUS TYPES OF INTESTINAL OBSTRUCTION**

**I MECHANICAL OBSTRUCTION**

**A NARROWING OF THE LUMEN**

**1 STRUCTURE OF BOWEL WALL**

**a Congenital Atresia** (see section on Congenital Atresia)

**b Imperforate Anal Canal and Rectum**  
**—Etiology**—Atresia of the anal canal or of the lower portion of the rectum occurs once in about every five thousand births. The division between the sexes is about equal. Not infrequently it is attended by the presence of other embryological defects.

**Embryological Anatomy**—Failure of the anal plug to break down brings about the condition of imperforate anus. Incomplete migration of the hind gut atresia of the rectum. The malformation in imperforate anus concerns almost solely the postallantoic gut, that is the portion of the hind gut caudal to the allantois that grows down and joins the anal plate. The abnormal development of imperforation therefore concerns only this segment of the gut and does not extend higher than the inferior portion of the primitive cloaca.

**Pathology**—Two types of imperforation are recognized viz., with or without abnormal fistulous communication of the terminal bowel. Stieda's classification on this basis is widely accepted. Of 114 cases of imperforation collected by Ziemendorff (1909) these divided themselves as follows with reference to Stieda's table:

Type I	Cases	Per cent
1 Anal atresia	98	24.6
2 Rectal atresia	16	14
3 Anal and rectal atresia	8	7
Total	52	45.6

Type II	Cases	Per cent
1 Vaginal fistula	38	33.3
2 Urethral fistula	11	9.6
3 Vesical fistula	9	7.9
4 External fistula	4	3.5
Total	62	54.3

The nature of the occlusion in imperforation may vary from a thin diaphragm to imperviousness of the entire length of the anal canal and rectum. Stenosis without actual atresia may also occur. Owing to the early segregation of the urinary and genital passages in the female vesical and urethral terminations of the rectum are unknown in that sex. The almost invariable site of termination of the fistulous tract is in the posterior commissure of the vagina. In the male communication with the prostatic urethra is usually established by a narrow tract when the communication is without the bladder the termination may be cloacal in type.

**Clinical Features**—In hospitals the occurrence of atresia is usually established when

an attempt is made to secure the baby's temperature with a rectal thermometer. In anal atresia casual inspection of the perineum serves to identify the nature of the lesion. When routine examination of the newborn is not regularly made, the presence of imperforation may escape detection until failure to evacuate meconium is noted. Vomiting and intestinal distention occur in most instances.

The degree or extent of the impervious or atresic bowel cannot be made out by the ordinary criteria of physical examination. If the infant is held in the inverted posture however the height to which the gas ascends



Fig 561—Manner of determining the degree of imperfection present and the order of magnitude of the surgical approach necessary to tap the distended gut. In the inverted posture gas mounts as high as the obstruction extends.\*

in the pelvic colon and rectum as indicated in a roentgenogram serves to determine the extent of the imperforation (Fig 564).

**Prognosis**—In occlusion of the anal canal or rectum without fistulous communication prolonged survival without the establishment of an external opening is impossible. Infants with vaginal termination of the rectum may frequently be seen because of an abdominal mass occasioned by the accumulation of feces above a narrow outlet. In the male fistulous termination in the urinary tract usually eventuates in pyelonephritis.

\* Wangersteen and Rice. Ann Surg 90 J B Lippincott Co

unless the communication is obliterated and an external opening is established for the escape of feces

**Treatment**—The early establishment of an avenue for the escape of gas and feces is indicated. Almost invariably this is best accomplished by means of a perineal incision (proctoplasty). A roentgenogram taken with the infant inverted indicates the depth at which the bowel will be reached. Recourse to colostomy is rarely necessary and should be avoided because of the increased risk. In vaginal termination of the rectum simple daily dilation of the narrow tract followed by its implantation through the fibers of the external sphincter in later childhood is indicated. The risk of the operative relief depends largely on the order of magnitude of the procedure found necessary to establish an outlet for the escape of feces

**c. Acquired Strictures—Etiology**—Stenosis of the bowel brought on by acquired strictures may be due to (1) inflammatory (2) neoplastic or (3) traumatic causes. Of these the third is the most infrequent and may be said to be a rare occurrence. Occlusion due to the formation of a stricture has been reported after blunt trauma to the abdominal wall. The usual circumstance in such instances is severance of the mesentery to a short segment of the intestine which accident is survived. Subsequently cicatrization of the intestinal wall occurs and stenosis supervenes. The more frequent occurrence is traumatic stricture after incarceration or strangulation of the intestine in a hernia particularly in the femoral canal.

The formation of a stricture may attend any ulcerative process in the bowel but is observed most commonly in intestinal tuberculosis. A tuberculous ulcer which has its axis transverse to that of the intestinal tract and which is usually exhibiting signs of healing gives rise to stricture that results in intestinal obstruction. These are frequently multiple. Hyperplastic tuberculosis an isolated type which has a predilection for the cecum may give rise to obstruction. Syphilitic strictures of the bowel have been known to give rise to obstruction. Similarly following on the ulceration of the bowel attending bacillary dysentery and typhoid fever strictures causing intestinal obstruction have

been observed. The ulceration in typhoid is in the axis of the bowel and the formation of a stricture is rare. Inflammation in diverticula (diverticulitis), commonly observed in the pelvic colon of persons past middle life rather commonly gives rise to large masses which obstruct the colon. Because of the not infrequent concomitant occurrence of carcinoma in this location of the colon an accurate differentiation is possible only by means of microscopic examination.

Obstruction due to a neoplastic process may be occasioned by either a benign or a malignant tumor. Benign tumors occur more frequently in the small intestine and the malignant in the colon with the exception of sarcomas which occur more frequently in the small intestine. Of the benign tumors lipoma myoma fibroma adenoma and angioma are the more usual offenders. All of these except adenoma show a predilection for the small intestine. An enterocystoma of congenital origin not infrequently associated with a persistent Meckel's diverticulum occasionally gives rise to intestinal obstruction. Gaseous cysts of the intestinal wall have been known to cause obstruction of the bowel.

**Pathology**—The majority of these lesions give rise to a simple obstruction of the bowel. Benign tumors of the small intestine and large bulky adenomas or carcinomas of the colon occasionally bring about occlusion by intussusception. The carcinoma tumors which occur in the small bowel have given rise to obstruction in about 16 per cent of the reported instances. These are to be differentiated from carcinoma of the small intestine by their reaction to the silver stain. Both give rise to metastases. Carcinoma as well as carcinoma tumors of the small intestine is usually single but may be multiple.

Carcinoma of the colon is a frequently observed cause of obstruction in older persons. Obstruction of the left half of the colon where the intestinal content first begins to assume solid form occurs eight times more often than in the proximal half. The sigmoid flexure with the narrowest lumen of any portion of the large bowel, is most frequently the site of obstruction in the colon. The anatomical arrangement of the flexures particularly the splenic flexure predisposes to obstruct on. When obstruction occurs as a result of a cecal carcinoma it is the small bowel that is obstructed.

Nine of every 10 cases of mechanical obstruction of the colon are due to carcinoma. About 40 per cent of the patients with carcinoma of the large bowel who present themselves for treatment come because of chronic or acute intestinal obstruction. Acute obstruction is most frequently observed in the annular sigmoid carcinoma in the sigmoid flexure.



Owing to the usual competence of the ileocecal sphincter an obstruction of the colon when attended by considerable distention tends to become strangulating in character. The ileocecal sphincter and valve usually behave like a check valve permitting fluid and gas to be forced into the colon but there is no escape of the contents of the distended colon back into the small intestine. At operation despite enormous distention of the entire colon the last few inches of the ileum are usually found to be not distended. The cecum has the largest diameter of the colon consequently it dilates most readily and usually shows the greatest effects of increased intraluminal distention (Fig. 5.59). Ulceration, hemorrhage and perforation observed most frequently in the cecum occasionally attend this type of obstruction when it remains unrelieved for some time.

**Symptoms**—A stricture of the small bowel whether due to a neoplastic process, inflammation or trauma usually gives rise to subacute attacks of intestinal colic. When the patient presents himself with intestinal obstruction *variable peristalsis* is often in evidence and loops of small intestine may be felt and seen through the abdominal parietes. The patient may have relatively long intervals of freedom from attacks. In most instances of obstruction of the small bowel through carcinoma progressive loss of weight and occasional attacks of pain and vomiting are usual. The finding of occult blood in the stool lends confirmation to this impression particularly if the stomach and colon are known to be free from disease. Because of the fluid character of the content of the small intestine narrowing of the lumen by the stenotic process must be considerable before obstruction becomes persistent. Such patients have come under the writer's observation with a story suggestive of intestinal colic but on examination no objective demonstration could be made of the existence of a block to the bowel by clinical or roentgen evidence.

In obstructions of the colon due to strictures which are largely neoplastic in character vomiting is frequently absent despite the presence of enormous distention. This occurrence is readily accounted for in the lack of participation of the small intestine in the distention. When the lips and usually the lower lip of the ileocecal valve are deficient regurgitation into the terminal ileum may attend colonic obstruction. When a duodenal tube is passed into the stomach no retention may be found. Antecedent attacks

of abdominal pain associated with temporary meteorism are frequent, a history of constipation extending back over some period of time is usual. The occurrence of blood or mucus in the stool suggests the presence of an ulcerative process in the bowel. Alternating periods of constipation and diarrhea may be complained of. Intestinal colic may however be the first evidence of the disease.

**Diagnosis**—The occurrence of intestinal colic and distention affords satisfactory evidence of the presence of an organic block in the bowel. The location of the distended intestinal coils is easily obtained on roentgen examination.

**Differential Diagnosis**—The exact nature of the obstructing agent may not be determinable until at operation. Incarceration of a gallstone in the intestinal tract, enteric intussusception and obstruction by an adhesive band cannot be adequately differentiated.

In obstruction of the colon a functional spastic ileus concerning essentially the large bowel may give rise to confusion. The picture of an organic occlusion in the bowel may be simulated closely and many patients with spastic obstruction of the colon have been operated on under the diagnosis of mechanical obstruction due to neoplastic stricture in the sigmoid flexure. Inspection of the roentgenogram showing the extension of the gaseous distention to the rectum and the administration of a barium enema usually serve to differentiate these conditions if the possibility of this confusing occurrence is only borne in mind. Occasionally compression of the pelvic colon from a pelvic mass may be mistaken for an intrinsic obstruction in the intestine but physical examination and the history usually serve to differentiate this condition. Diverticulitis and obstruction by neoplasm often cannot be distinguished without the aid of the microscope.

**Prognosis**—The mortality of intestinal obstruction due to malignancy is in the neighborhood of 50 per cent. This unwarranted mortality is compounded in part through continuance of surgeons to perform cecostomy in operation which cannot be done aseptically in the presence of great distention. General adoption of the type of op-

erative procedure depicted in figure 565 will lead to a lowering of the mortality. Benign strictures carry considerably less risk.

*Treatment*—Frequently patients with subacute obstruction of the small intestine due to stricture can be tided over to a non-obstructive phase by the employment of suction applied to an intying duodenal tube and the condition rectified in one operative procedure. If, however, the distention is

low, is often the wisest procedure. Occasionally an enteroanastomosis followed by excision of the lesion at a subsequent operation may be performed.

In obstruction of the colon a decompression type of operation is in order. Because of the action of the ileocecal valve, suction applied to a duodenal tube is of no value, except in cases in which the obstructive element is mild. Here, frequently the patient

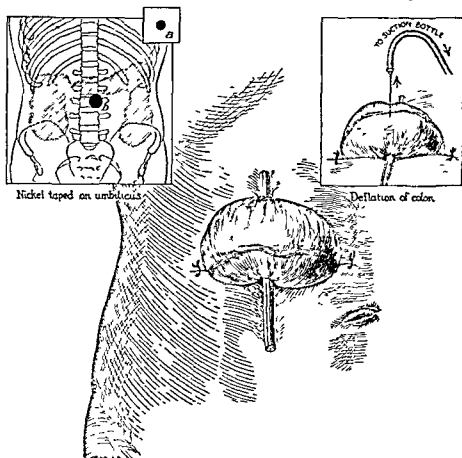


Fig. 565—Technic of decompressing the distended colon. Upper left sketch of a roentgenogram. A five cent piece (a) was taped over the umbilicus (b). Upper right the method of deflating the colon on completion of the operation is shown. After a few such aspirations, the bowel is incised, and before it is finally cut across a tube is inserted. The tension in the bowel is determined before its contents are aspirated. This aseptic type of operation for acute obstruction is attended by a low mortality.\*

great and the nature of the obstruction remains somewhat in doubt, operation is in order. No extensive surgical procedure should be contemplated in the presence of obstruction, particularly operative procedures which require opening of the bowel. Enterostomy frequently suffices. Resection and anastomosis carry a high mortality and should not be attempted under ordinary circumstances. Exteriorization of the loop of intestine, especially if the obstruction is

may be carried over to a non-obstructive phase by such means and the lesion itself directly attacked. In acute obstruction it might appear that appendicostomy or cecostomy would be the operative procedure of choice. The former deviates the fecal stream incompletely; an aseptic cecostomy is difficult to perform in the presence of an acutely distended colon. The writer has come to em-

\* Wangenstein: Intestinal Obstructions. Charles C. Thomas Publisher.

ploy a transverse incision directly over the transverse colon (Fig 565) in dealing with acute obstruction of the colon. It can be done aseptically and with little risk and constitutes a satisfactory and effectual method of decompressing the distended colon. When the obstruction is in the hepatic flexure or the ascending colon, that distended segment of gut may be exteriorized and tapped as indicated in figure 565. An alternative method would be to perform ileostomy on the terminal portion of the ileum pushing the catheter through the ileocecal valve into the distended cecum.

## 2 OBSTRUCTION

**a Intestinal Obstruction Due to Gallstones.—***Etiology.*—In cases of obstructions due to gallstones there is invariably an abnormal communication between the biliary passages and the intestine. Most frequently this internal biliary fistula is established between the gallbladder and the duodenum though communication with some other portion of the alimentary canal such as the stomach jejunum ileum or colon is occasionally found. Infrequently the communication is between the common bile duct and a portion of the intestinal canal. Instances are reported in which an intestinal obstruction is said to have occurred in the absence of such an abnormal communication. In such instances however it would appear unlikely that the gallstones were large enough to cause a mechanical block of the bowel for rarely do gallstones of that size pass through the ampullary opening of the choledochus. However occasionally gallstones not large enough to block the lumen of the bowel do cause symptoms of bowel obstruction. In such instances however a dynamic or spastic obstruction must be brought about through the agency of the stone. Obstruction due to a gallstone though infrequent is decidedly not a rare occurrence. The usual site of lodgment of the stone is the lower portion of the ileum but occasionally it is found in the jejunum or even in the sigmoid flexure of the colon. Stones large enough to occlude the lumen of the intestine are usually about the size of a walnut. Round stones are much more likely to cause obstruction than stones of equal weight but greater length. Enlargement of a gallstone during its passage through the intestine may also occur. It is especially likely to happen if the stone remains in any portion of the intestine for a considerable length of time and particularly when medicaments such as bis muth subnitrate calcium or magnesim carbonate are taken orally. Instances in which obstruction due to gallstones has occurred in the same person more than once are on record. Gallstones obstruct the bowel three times more frequently in women than in men. Persons of middle life and a advanced years are most often attacked.

*Pathology.*—Obstruction due to a gallstone is usually of the simple variety in which a mechanical block alone is present. Occasionally such an obstruction partakes of the nature of a volvulus because of the fact

that when fluid and gas accumulate above the point of obstruction owing to the increased weight of the segment such a loop may undergo torsion. A tendency for perforating ulcer to form at the site of incarceration of the stone in the bowel is well known.

*Symptoms.*—There are no clinical features peculiar to this type of obstruction. Frequently an antecedent history of disease of the gallbladder or cholangitis may be obtained. Intestinal colic in the presence of unexplained jaundice should suggest the possibility of obstruction due to a gallstone.

*Diagnosis.*—Though the presence of intestinal obstruction is rarely demanding of proof, an accurate preoperative diagnosis is rarely made. Occasionally the stone may be visualized in the distended bowel on the roentgenogram.

*Prognosis.*—The outlook is somewhat grave (mortality of about 50 per cent). This is accounted for partly by the fact that the patients frequently come late to operation and partly because the opening of the intestine in order to extract the stone in the presence of obstruction may result in peritonitis. Opening of the bowel and removal of the stone without soiling will lead to a lessening of the mortality. Of the last 4 patients operated on at the University Hospitals, none died.

*Treatment.*—Operation at the earliest possible moment is the safest procedure. The stone must be removed without spillage. Aseptic removal can be effected by placement of presection sutures which are pulled aside for the placement of the transverse incision in the bowel. As soon as the stone is removed the sutures are tightened and tied.

**b Intestinal Obstruction Due to Foreign Bodies.**—Children occasionally swallow pebbles coins or circular whistles that may give rise to intestinal obstruction but the majority of these foreign bodies pass through the intestinal canal without special event. Demented or hysterical persons not infrequently swallow objects of the most unusual character that lodge in the intestine and cause obstruction. Pins needles tooth teeth spoons nails and screws have been removed. Indigestible materials such as bran licks of oats and fruit stones have been known to accumulate in the intestine or to contribute to the formation of masses in the bowel which cause obstruction. Should a structure exist in the intestine such bodies are particularly likely to obstruct it.

**c Obstruction Due to Enteroliths.**—Enteroliths occasionally give rise to obstruction in man but commonly in horses. Their occurrence in the human vermiform

form appendix is a matter of general knowledge. Enteroliths that cause intestinal obstruction may be divided into three classes: (1) true enteroliths, (2) mixed enteroliths or phytobezars and (3) intestinal concretions due to ingestion of medicaments. True intestinal stones or enteroliths present usually a small organic nucleus. They develop in the presence of stasis and in an alkaline medium (Winterstein 1923). They are usually found therefore in the large intestine and occasionally in the terminal ileum. Their occurrence in diverticula along the mesenteric border of the small intestine has been repeatedly noted. The occasional presence of enteroliths in Meckel's diverticulum is well known. Alkaline mineral salts of phosphorus, calcium or ammonium may be deposited about the central nucleus of the stone. Mixed stones are formed usually by the husks or pitting of fruits. Intestinal contents are then deposited about them in the alkaline medium of the lower intestinal canal. Following the prolonged ingestion of calcium, magnesium, bismuth and salol, intestinal stones may form. In painters and shellac workers development of such stones has been observed.

Clinical features of enteroliths that cause intestinal obstruction are not unlike those due to gallstones or other foreign bodies in the intestinal tract. Some are radiopaque and may be visible in roentgenograms.

**Treatment.**—The principles detailed under the caption "Intestinal Obstruction Due to Gallstones" are pertinent here. If the obstruction is incomplete, suction applied to a duodenal tube will frequently permit removal of the foreign body in an unobstructive phase. If the distention is considerable, temporary exteriorization of the involved segment of the intestine is in order.

**Intestinal Obstruction Due to Worms.**—Infestations of *Ascaris lumbricoides* occasionally give rise to intestinal obstruction, usually in children. Occasionally the symptoms have followed the institution of vermifuge therapy. Rost has isolated from the *Ascaris* a substance which exhibits a marked stimulating effect on the tonus of the intestine of the cat. The administration of vermifuge may liberate from the worm a toxic substance that precipitates a spasm of the bowel. Occasionally the presence of these worms may be demonstrated roentgenographically. If the obstruction is incomplete, as is usually the case, the temporary employment of duodenal suction will result in the automatic establishment of intestinal continuity. If the mass of worms persists, however, operation may be in order. Wherever possible the intestine should not be opened for the *Ascaris* exhibit an unusual tendency to work its way through the suture line. This has been reported after gastric resection and may also be observed in the experimental laboratory following enterostomy on the dog's intestine.

**Intestinal Obstruction Due to Meconium in the Newborn.**—Epithelial plugs adherent to mucous membrane which when unrolled give the appearance of long flat casts of the intestinal wall have been known to give rise to obstruction in the newborn (Fialto 1923).

**Fecal Obstruction of the Bowel (Hirschsprung's Disease).**—**Etiology.**—A somewhat frequent cause of fecal obstruction of the bowel is congenital enlargement of the colon and rectum. The first com-

plete description of this disease was given by Hirschsprung in 1856 and since then this disease has been known by his name.

**Prognosis.**—The risk as far as the acute obstruction is concerned is not great though if the obstruction goes unrelieved perforation of the colon may occur. Ultimate permanent relief from the condition demands correction of the underlying difficulty.

### 3. INTESTINAL OBSTRUCTION DUE TO COMPRESSION FROM WITHOUT

**Etiology.**—In such instances the mechanism usually consists of compression of the bowel at some fixed point by a tumor mass or other mechanism extrinsic to the bowel. The sites at which such obstructions frequently occur are (1) the retroperitoneal duodenum where the duodenum is crossed by the superior mesenteric artery, (2) the terminal ileum at its insertion into the cecum and (3) the pelvic colon. The bony landmarks of the pelvis account for the frequency with which an incarcerated mass in the pelvis may compress the pelvic colon and give rise to obstruction. Tumors of the mesentery or large retroperitoneal tumors which fix the intestine permit the bowel to become squeezed and occluded by a small mass which a larger mass would fail to accomplish if the bowel were mobile enough to escape. Inflammatory masses particularly when in the pelvis may obstruct the bowel by pressure. The added factor of organization of fibrinous adhesive bands linking the bowel may occasionally play a not wholly minor role in the development of obstruction in such instances.

**Clinical Features.**—The history, physical examination and roentgen observations usually establish the diagnosis. In so-called arterio-mesenteric ileus there may be frequent vomiting. Aspiration of the stomach and having the patient lie prone so that the drag of the mesentery falls away from the duodenum usually afford relief. Roentgen examination with barium usually demonstrates dilatation of the duodenum up to the point where it is compressed by the superior mesenteric artery. The scout film in other types of obstruction by compression usually indicates the site of the obstruction.

**Treatment.**—The obstruction is usually incomplete and operation is rarely demanded for relief of the distention. An anastomosis between the retroperitoneal duodenum and the first loop of the jejunum affords adequate relief in many instances of so-called arterio-mesenteric ileus. Some cases of so-called arterio-mesenteric ileus are due to compressive developmental bands which cause narrowing of the lumen of the duodenum. In these cases it is best, as Laill (1922) has indicated, to free the bowel rather than make a new stoma. If the obstructive mechanism is inflammatory, suction applied to a duodenal tube often adequately cures the distention and under conservative management including the application of local heat to the abdomen and to the region of the bowels where possible the obstructive element is satisfactorily dealt with. Occasionally operation is in order to remove the mass. Celiotomy occasionally must be performed particularly for the "plaster of Paris" inflammatory surrounding parametritis and cellulitis of the pelvis.

## B. INTESTINAL OBSTRUCTION DUE TO ADHESIONS AND BANDS

**Frequency**—In every series of cases of intestinal obstruction, this group constitutes from 30 to 40 per cent of the cases

**Etiology**—There is uniform agreement that most adhesions causing intestinal obstruction develop after operation. Of 162 cases of adhesive ileus reported by Flesch-Tlebesius (1920) operation had been previously performed in 113 cases. Appendectomy for suppurative appendicitis necessitating drainage is a most frequent antecedent. Operations on the female pelvic organs rank second as a precursor of postoperative adhesions causing obstruction. It is an interesting fact that there appears to be no direct correlation between the location or presence of the adhesions and the development of intestinal obstruction. Bryant (1923) in performing 297 routine postmortem examinations with the point in mind of determining the occurrence of adhesions found that the transverse colon in both males and females was most frequently involved. Next in frequency adhesions were found around the gall bladder, duodenum, omentum, ascending colon, hepatic flexure, appendix, liver and descending colon.

Adhesions that give rise to intestinal obstruction may be of congenital origin, as the fold that binds the terminal ileum to the cecum; adhesions may form also in consequence of external blunt trauma or following intraperitoneal hemorrhage and other inflammations of all varieties and following tumor implants in the abdomen. Adhesions after endometrial transplants in the pelvis are not infrequent. The adhesive type of tuberculous peritonitis commonly causes chronic intestinal stasis and occasionally acute intestinal occlusion.

Adhesive bands may cause obstruction by actual compression of the bowel through traction, kinking of the intestine or by effecting a volvulus or torsion of the bowel. Meckel's diverticulum may give rise to obstruction by any one of these mechanisms. Bands causing obstruction usually concern the small intestine; when the large intestine is involved the flexures of the colon are usually implicated, the hepatic splenic and sigmoid flexures. Adhesive bands causing obstruction may be narrow, representing mere threads, or they may be broad, peritoneal folds.

Intestinal obstruction through the agency of adhesions following operation may occur at any time—most frequently within the first four weeks, but at any time thereafter and have been observed years later.

**Pathology**—Adhesive bands may give rise either to simple intestinal obstruction or to the strangulation type. The most frequent occurrence is simple occlusions of the bowel by compression, kinking or traction. Volvulus or torsion is not infrequent through the medium of abnormal bands in the peritoneal cavity. Wilms (1906) has described this variety of intestinal obstruction in considerable detail under the special caption of "Knotting of the Small Intestine."

**Clinical Features**—Intermittent gas pains are the patient's first complaint. If the condition occurs in the immediate postoperative

convalescence the nature of the lesion perhaps is not suspected until nausea and vomiting occur. A roentgenogram taken at that time usually shows the distended intestinal coils. The audition of loud intestinal borborygmi at the height of the pain establishes the presence of intestinal colic, which together with the roentgenogram establishes a diagnosis of intestinal obstruction. If the adhesive bands merely block the continuity of the bowel, tenderness is not found. If a loop of intestine is strangulated, sanguinous fluid escapes into the peritoneal cavity, giving rise to tenderness of the abdominal wall. The insertion of obstructing adhesive bands to the anterior parietal peritoneum occasionally gives point tenderness in simple obstruction. Visible peristalsis is rarely noted in acute adhesive obstruction. The roentgenogram indicates whether the obstruction is complete or incomplete.

The history of a previous operation is often significant. The story of antecedent previous attacks of intestinal colic accompanied by nausea and vomiting suggests the diagnosis. In fact, the diagnosis may frequently be made over the telephone.

**Differential Diagnosis**—In the immediate postoperative period, especially following operation for an inflammatory process, the existence of peritonitis may suggest itself. In such a circumstance, however, the abdomen is silent, whereas the abdomen in intestinal obstruction presents intestinal colic. Occasionally it is difficult to distinguish with accuracy between an inflammatory lesion causing simple obstruction and an adhesive mechanism occasioning torsion and strangulation of the intestine. Sometimes it is impossible to make a differential diagnosis without performing an exploratory laparotomy.

**Prognosis**—The outlook is essentially measured by the nature of the manner in which the intestine is obstructed. Whereas a general mortality of 40 per cent is reported, timely recognition and judicious treatment should result in a much lower percentage (Wangensteen et al, 1939).

**Treatment**—A partial adhesive obstruction may be satisfactorily treated in many instances by suction applied to an intubated duodenal catheter. When the obstruction is complete, as indicated by the absence of gas

in the colon after the administration of enemas operation is often advisable. In early instances of simple obstruction the operation of election viz locating and determining the exact nature of the obstructive mechanism may be done as well as relief of the imprisoned bowel. In late instances simple enterostomy is the operation of choice. In strangulation obstruction which is heralded at operation by the presence of hemorrhagic fluid and an infarcted segment of intestine the viability of the loop must be determined. No matter how ill the patient may be if the bowel is not viable it must be excised. In the small bowel the tendency is increasing to do primary resection followed by immediate closed (aseptic) anastomosis.

### C HERNIA

1 **Intestinal Obstruction Due to External Hernia**—*Etiology*—External orifices at which hernia occurs most frequently are the inguinal femoral and umbilical. These are also the hernias that most frequently give rise to intestinal obstruction and symptoms of strangulation. Less frequently strangulation may be seen in incisional epigastric, obturator lumbar sciotic and perineal hernias. In 903 operations for hernia at the Hospital for Ruptured and Crooked Bull and Coley (1907) report 24 cases of strangulation. Strangulated hernia is essentially a disease of active adult life most cases occurring between the ages of twenty and fifty although it may obtain from infancy up through old age.

In inguinal hernia the external ring constitutes the most frequent cause of strangulation. Less frequently strangulation occurs at the internal ring and occurs on all the constriction may be in the sac. Right inguinal hernia is more common than left and similarly strangulation on the right side is observed more frequently than on the left. Because of the more gradual development of direct inguinal hernia and the progressive stretching of the hernial orifice strangulation only infrequently occurs in direct hernia.

Femoral hernia ranks as one of the common causes of intestinal obstruction of the strangulating variety. Femoral hernia is much less common than inguinal still the frequency with which strangulation occurs in femoral hernia closely approximates that of the inguinal group. The rigid walls formed by Poupart's Ligaments and Cooper's Ligaments constitute a treacherous aperture through which a loop of bowel may protrude. In consonance with the greater incidence of femoral hernia in women strangulation also occurs more frequently in the female. The rigid fascial insertions into the linea alba at the umbilicus make for frequent strangulation of the intestine at this site. In the newborn owing to occasional lack of fusion of the abdominal walls at the umbilicus a large defect may be present into which intestine and even portions of the liver and stomach may become herniated.

*Pathology*—Hernial orifices through which the contents of the abdomen may protrude for the most part have hard fibrous edges which quickly compress and strangulate the intestine as it makes its way through such a channel. In consequence the bowel is quickly deprived of its blood supply and tissue necrosis develops unless the bowel is released from the compression. At operation on changes are noted in the color of the intestinal tissue depending on how long it has been ensnared in the hernial orifice. The bowel is distended with fluid and gas. Usually it is empty when it makes its way into the hernial canal and when gas and fluid are driven in under the motive force of peristaltic contraction their progress is impeded by the obstruction offered at the distal end of the loop. In those instances in which considerable gas and fluid fail to find their way into the strangulated segment the effects of pressure are often manifest only at the site where the bowel is constricted. When the intestine is released from the strangulating mechanism the remainder of the tract may fail to show any effects of the constriction. Invariably however if the intestine is considerably distended the effects of increased intraluminal tension are manifest throughout the segment being most in evidence at the site of constriction.

*Clinical symptoms* of strangulated hernia are those of intestinal obstruction with the addition of a painful tender and often tense swelling at one of the hernial orifices. The history of the previous existence of a hernia is usually obtained occasionally, however strangulation may be the first warning of such a protrusion. A tympanic note can frequently be demonstrated over the imprisoned bowel. In the presence of considerable exudation into the sac this note may be dampened somewhat but is never dull as is the percussion note produced by incarcerated omentum. In femoral hernia particularly impingement of a portion of the intestinal wall by the tendinous margin of the femoral canal is likely to occur without actually establishing the presence of a block to the continuity of the intestinal current (Richter's hernia). A similar occurrence may take place at the inguinal epigastric umbilical and obturator apertures though less frequently than in the femoral canal. Occasionally a strangulated hernia will only have omentum in its sac even though the symptoms of vomiting suggesting intestinal occlusion may be present. Pain down the inner side of the thigh as far as the knee (Howship Romberg sign) corresponding to the sensory distribution of the obturator nerve in the presence of symptoms of intestinal obstruction suggests strangulation in an obturator hernia but it is only inter-

quently diagnosed prior to operation. Vaginal or rectal examination may disclose a tender mass above the inferior ramus of the scerum. Perhaps nowhere is the value of early treatment of intestinal obstruction better illustrated than in strangulated hernia. Bower (1927) found that the average length of time elapsing between the onset of symptoms and operation for strangulated hernia was thirty-one hours, whereas for cases of intestinal obstruction within the abdomen the time was seventy-six and six-tenths hours, the latter time being greater by 177 per cent.

**Prognosis.**—Braun and Wortmann (1924) state that 1795 patients with strangulated hernia were seen at the Friedrichshain Hospital in Berlin during the years between 1903 and 1922. In this group death occurred in 280 cases (15.6 per cent). In 1509 of the entire group no gangrene was present. Of these patients 136 died (a mortality of 9 per cent). Of 286 patients with gangrene 144 died (a mortality of 50.9 per cent).

**Treatment** for all cases of strangulated hernia is immediate operation with release of the intestine from the strangulating mechanism. The incision should generally be a little more generous than is ordinarily employed to permit of adequate exposure. After interruption of the strangulating mechanism the hernial sac should be opened and the condition of the bowel ascertained. The return of normal lustre to the bowel and pulsation to the vessels indicates that the bowel is viable. In instances of doubtful viability primary resection should be done. Surgical procedures on the intestine if necessary are occasionally best done through a separate incision after the strangulation has been reduced.

Reduction of the strangulated hernia by taxis is of doubtful value unless the patient is seen within a short time of the strangulation. Taxis is better not attempted. In a comprehensive report on the value of spinal anaesthesia in ileus Duval (1927) refers to several cases in which perforations were found in the bowel after reduction of a strangulated hernia by taxis.

**2 Intestinal Obstruction Due to Internal Hernia.**—Internal hernia occurs relatively infrequently. During an eighteen-year period in which 1795 patients with ex-

ternal hernia were operated on at the Friedrichshain Hospital in Berlin only 21 patients with internal hernia presenting features of obstruction were treated during the same interval of time. Strangulation may be caused by (1) diaphragmatic hernia (2) hernia into the foramen of Winslow (3) hernia of the paraduodenal fossae (4) hernia into a persistent hole in the mesentery (5) hernia into the intersigmoid fossa and (6) paracecal hernias. Some of these may not be true hernias in the restricted sense since they have no peritoneal covering.

### D VOLVULUS

Volvulus or torsion of the bowel occurs usually in the sigmoid flexure. A long flexure in which the limbs of the loop are closely approximated predisposes to its occurrence. It is also significant that in most instances in which volvulus of the sigmoid flexure obtains an unusually large bowel or pseudo-megacolon with a long mesentery is present. Less frequently volvulus involves the caecum and terminal ileum and less commonly the small intestine, stomach or transverse colon. The rarity with which volvulus of the transverse colon is seen bespeaks the importance in the development of torsion of the narrow attachment of the mesentery. The transverse colon despite its extreme range of motion escapes frequent twisting because its points of fixation at the hepatic and splenic flexures are so far removed from one another.

In most statistical studies of intestinal obstruction volvulus constitutes about 10 per cent of the total number of cases. In Russia and Serbia volvulus appears to occur frequently. In 215 cases of intestinal obstruction reported by Ierling (1925) from a Russian surgical clinic 111 or more than half were cases of volvulus. Wortmann grouped the reports of a number of Serbian authors and found that in 393 cases of intestinal obstruction volvulus was present 127 times. All writers stress the greater length of the intestine and the significance of the vegetable diet of the Russian people as a contributing factor to the frequent occurrence of volvulus. According to Braun and Wortmann C. Reelmann found abnormally long flexures of the pelvic colon in only 4.0 per cent of the postmortem examinations made in Germany, whereas Samson in a similar material in Russia found 20 per cent. Long periods of fasting followed by indulgence in overeating a common practice among the Russian peasants, are believed to play a causative role. Volvulus occurs three or four times more frequently in men than in women. The greatest incidence of the disease occurs in middle and advanced years.

Volvulus of the cecum and small intestine has as its essential cause an abnormally mobile segment of small intestine with inadequate fixation of its mesentery. In such cases the cecum usually possesses a continuation of the mesentery of the terminal ileum. Other cases present evidence of incomplete rotation of the right colon. Overfilling and gaseous distention appear to be contributing factors.

**Pathology**—Torsion of from 180 to 360 degrees is usual but in cecal torsion involving the small intestine a twist of from 50 to 70 degrees may be seen. When there is a broad mesenteric attachment a twist of more than 180 degrees is unusual. Mesenteric cysts occasionally give rise to torsion of the intestine and volvulus of the small intestine may occur when a gall stone blocks the lumen.

Circulatory changes vary with the degree of vas-

cussion. Frequently such patients have had previous attacks of pain from which recovery has been spontaneous.

Visible peristalsis may frequently be observed in torsion of the sigmoid flexure less commonly in volvulus of the cecum and small intestine. In the presence of marked vascular occlusion constitutional symptoms of severe degree may be present, quickening of the pulse with hurried respiration and abdominal tenderness and rigidity are frequently noted. If the obstruction remains unrelieved symptoms of severe circulatory shock due to loss of blood into the strangu-



Fig. 366—Platograph at necropsy in a case of volvulus of the sigmoid flexure. Note the enormous distention of the segment which has under one torsion. Its wall is thick and discolored because of the hemorrhagic infarction. The proximal colon is somewhat distended but the small intestine is not at all distended because of the action of the ileocecal sphincter. (Courtesy of Dr. N. F. Link)

cular occlusion are regularly present. Free peritoneal fluid, gangrene and even perforation of the twisted segment may be seen. The strangulated loop presents evidence of distention with gas and fluid. The segment proximal to the site of torsion is also dilated. The direction of the twist in torsion of the small intestine is usually clockwise though counter-clockwise twists are observed. In torsion of the cecum the direction of the twist is about evenly divided. In the sigmoid flexure the clockwise twist appears to be more frequent.

**Clinical Features**—The distention is often extreme (Fig. 366). The distended coil corresponding to the twisted sigmoid flexure or cecum can frequently be seen over the abdomen and may be palpated as an elastic tumor exhibiting marked tympany on per-

cutaneous auscultation. The roentgenogram indicates the location of the obstructed intestinal coils.

**Differential Diagnosis**—Mesenteric thrombosis, acute pancreatitis, peritonitis and strangulation of an internal hernia may mimic torsion of the lower very closely. The establishment of the presence of intestinal colic indicates that some type of intestinal occlusion is present and the peritoneal irritation incident to the escape of blood into the peritoneal cavity indicates the necessity for operative intervention. Stenosing carcinoma of the sigmoid flexure may be confused with volvulus of the sigmoid flexure.



Spastic colitis with gaseous distention of the colon may occasionally simulate the picture of torsion

**Prognosis**—The mortality in intestinal torsion is about 50 per cent. In those cases requiring excision because of gangrene, the mortality has been about 80 per cent.

**Treatment**—Mild torsion sometimes can be relieved by the administration of a barium enema and detorsion of the colon can be observed under the fluoroscope. In most instances, however, operation is indicated. If the operation is performed soon after the symptoms develop, simple untwisting of the strangulated segment alone may suffice. If the strangulated loop is considerably distended, puncture and aspiration of its content may facilitate detorsion with less risk of spillage. If the vascular occlusion has been of long standing and is severe, circulatory changes in the intestine frequently necessitate excision of the segment. In the sigmoid flexure under such circumstances exteriorization after the Mikulicz method may be indicated. In volvulus of the small intestine, if the strangulated segment is long, a primary anastomosis is usually the operation of choice, but if the devitalized segment is short and in the lower ileum, exteriorization is safer.

It is well known that following detorsion, volvulus of the sigmoid flexure often recurs. The intestine may be fixed by means of plication, colopexy or lateral anastomosis, but usually excision after the Mikulicz method or primary resection is the operation of choice for recurrent torsion of the sigmoid flexure.

### E. INTUSSUSCEPTION

The frequency with which intussusception occurs varies widely in different countries. In England, Denmark and Australia it constitutes one of the most frequent varieties of obstruction observed. In the United States it appears to be definitely less frequent. About 75 per cent of all instances of the disease are seen in children under two years of age, more than half of the cases occur during the first year of life, and most of these are observed between the fourth and ninth months of life. The remaining 25 per cent occur throughout the years, being more frequent in early childhood than later.

The disease usually affects healthy infants. It occurs three times as frequently in the male. In intestinal invaginations observed in infancy an etiological agent is usually not apparent. In adults on the contrary a tumor of the bowel, Meckel's diverticulum or ulcer

affords satisfactory evidence of an etiological role in about 70 per cent of instances. Intussusception occurs most frequently at the ileocecal junction where vigorous peristalsis is countered by antiperistalsis in the cecum. This occurrence may have some significance as to its genesis. A large number of the cases occur at the time of weaning and it is believed that this change in the diet leads to intestinal spasm.

**Pathology**—Cases of intussusception may be classified as representing either large or small intestinal invaginations. Intussusception of the large intestine may be ileocecal in which the head of the cecum forms the apex of the invaginated bowel, or a pure colic invagination. In the small intestine there may be ileocolic invagination in which the lower ileum prolapses through the ileocecal valve, or a pure enteric invagination.

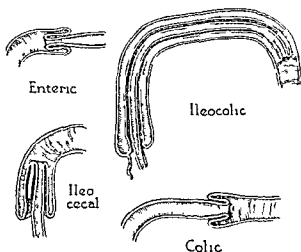


Fig. 567—Types of intussusception.

Occasionally a loop of the jejunum may telescope through a gastroyejunostomy stoma into the stomach. In the presence of a pyloric tumor the stomach has been known to telescope into a dilated duodenum. Intussusception of the appendix into the colon has occurred several times.

The usual intussusception consists of three cylinders, viz. internal and returning layers constituting the intussusceptum. The outer tube is known as the intussusciens or ensheathing layer. A double intussusception presents 5 cylinders and as many as 7 may be present in a compound intussusception.

Most intussusceptions occur in the neighborhood of the termination of the ileum. Ileocolic intussusceptions appear to be most frequent, accounting for about 60 per cent of instances. The ileocolic variety occurs in about 30 per cent of cases and the remainder are fairly evenly divided among enteric, colic, multiple and double intussusceptions. Intussusception is almost invariably of the descending variety but ascending varieties do occur.

The obstruction in intussusception is afforded by the active contraction of the sheath, especially at the neck; actual block of the lumen does not occur. The continuity of the intestinal lumen between oral and distal segments remains intact and in chronic intussusception

• Wangenstein: Intestinal Obstructions. Charles C. Thomas Publisher.

in which the changes in the intestinal wall are not so marked the intestinal current is preserved. The greatest alteration in the bowel in acute intussusception occurs in the intussusceptum. The walls of the invaginated segment rapidly become edematous stiff and engorged with blood. Extravasation of blood into the lumen occurs. Acute intussusceptions tend to become irreducible rapidly owing to the changes in the intussusceptum. Ulceration, gangrene and perforation of the invaginated bowel may develop in irreducible intussusception. The bowel above the obstruction is usually dilated and presents some evidence of congestion. In chronic invagination the bowel may undergo considerable hypertrophy.

**Clinical Features**—There are four cardinal symptoms of intussusception: (1) periodic attacks of pain, (2) vomiting, (3) passage of mucus and blood by rectum and (4) presence of a palpable tumor. Pain and vomiting are practically constant in occurrence. The sudden onset of painful seizures in a previously healthy infant is characteristic of intussusception. After a little the infant seemingly recovers, but in a little while he cries as if in pain. Alternating periods of pain and relief occur again and again.

Clubbe (1921) found that in 97 per cent of his cases blood was passed by rectum in from two to ten hours following the onset of the seizure. [Blood may be demonstrated by digital examination of the rectum.—Ed.] Enteric invaginations may not present blood in the stool. In pure colic intussusception blood is constantly in the stool early. An abdominal tumor is felt in about 60 per cent of instances. The pure enteric invaginations are notably difficult to feel. Clubbe states that only twice in 253 operations which he has performed for intussusception did he open the abdomen without having previously palpated the tumor. In ileocecal invagination the tumor is usually felt as a banana-shaped area to the right of the umbilicus stretching up toward the right costal margin; it may however be present on the left side of the abdomen as is usual in the more mobile ileocolic invaginations which may occasionally be palpated by digital examination of the rectum imparting to the examining finger the consistency of the uterine cervix. Enteric invaginations are always short and very small mobile tumors lying in the neighborhood of the umbilicus. In colic invaginations the tumor is usually found on the left side of the umbilicus in line with the descending colon.

The tumor of intussusception stiffens with the painful seizures and relaxes when the peristaltic rush is over. With the succeeding attacks of colic it advances its position and increases in size. The administration of 1 Gm. or more of chloral hydrate to infants in whom intussusception is suspected relaxes the infant and helps to establish the presence of a tumor. The abdominal wall may become moderately rigid during the painful seizure owing to the intestinal contraction. Distention is a rather late sign. It should be mentioned that intussusception is the one variety of strangulation obstruction in which tenderness and rigidity of the abdominal wall are frequently absent. This is readily explained in that the ensheathing cylinder which contains the strangulated intussusception is normal and that the greater exudation occurs inside this normal ensheathing cylinder. Occasionally however slight blood-tinged fluid may be present in the peritoneal cavity giving rise to tenderness.

**Differential Diagnosis**—Enterocolitis, appendicitis, mesenteric thrombosis, rectal prolapse and Henoch's purpura occasionally must be differentiated. Usually the findings in typical instances of intussusception are so characteristic that the disease is readily identified. In atypical instances however some of these may be difficult to differentiate. In intussusception blood is not mixed with the stools as it is in enterocolitis. In the latter both fever and constitutional disturbance are marked from the onset of the illness. Appendicitis rarely occurs in children under two years of age and blood in the stool is infrequent. Mesenteric thrombosis and arterial embolism are essentially diseases of advanced age and a tumor is rare. In rectal prolapse intestinal obstruction does not exist and the examining finger may readily detect the nature of the protruding bowel. Intussusception has been known to occur during the course of Henoch's purpura. Patients with purpura are usually older than those with typical intussusception and other evidences of purpura such as rash, pains in the joints, hemarthrosis or hematuria are frequently manifest. The constitutional symptoms usually overshadow the abdominal features—abdominal pain, vomiting, diarrhea, melenæ—which

may be present The blood in the stool is intimately mixed with the feces A palpable tumor may develop as a result of hemorrhage in the intestine and cause an actual obstruction

**Prognosis**—In the best available series of cases reported the mortality has been as low as 3 or 4 per cent (Clubbe 1901 Taylor, 1925 Hipsley 1926 1937) The more usual mortality is from 10 to 20 per cent In late cases necessitating resection the risk is always great particularly in the case of infants

**Treatment**—Early reduction of the invagination by operation is preferable No matter where the tumor presents in intussusceptions of infancy a short right rectus incision should be made a little below the umbilicus The invaginated intestine is pushed backward from below, only the most gentle traction being exerted on the invaginated bowel toward the completion of the reduction if necessary The initial portion of the reduction is accomplished within the abdomen guided only by the sense of touch The reduction of the apex of the intussusception is the most difficult part of the procedure and should always be carried out under direct vision

When the interval following the onset of the disease has been fairly short reduction of the intussusception is accomplished with relative ease When strangulation has been present for some time reduction may be impossible In such instances the bowel must be dealt with in some other manner A lateral anastomosis between segments of the bowel proximal and distal to the intussusception is usually safer than excision of the irreducible segment Infants in whom this disease usually occurs notably tolerate excision of the devitalized bowel poorly Clubbe states in his monograph that only 19 successful resections for gangrene or irreducible invaginations in children under one year have been reported If reduction of the intussusception is accomplished and it is found that the intestine is not viable in adults it is wiser to do a two stage resection in the first the devitalized intestine is exteriorized in the second the continuity is reestablished by suture Occasionally following the reduction of intussusception the patient has a high fever for a few days an in-

dication of impaired viability of the bowel wall Mr Associate Clarence Dennis did a successful primary resection for a gangrenous irreducible intussusception in a two month old infant A carefully performed closed resection should lower the mortality in late cases In the main however the greater salvage of life will attend surgical reduction of the invaginated bowel before resection becomes necessary

**Non Operative Reduction**—Hirschsprung (1905) gained worldwide renown for his successful reduction of intussusception by the non operative method In early intussusception the invaginated intestine may be simply forced back by the administration of a barium enema under gravity pressure of 3 feet In infants in whom invagination is likely to occur in the neighborhood of the cecum complete filling after the intussusception has been pushed back indicates that the reduction has probably been complete However in children past the time of life when intussusception is frequently observed the method should not be employed because of the frequency with which compound intussusception occurs

**Recurrent Intussusception**—Acute intussusception rarely occurs Clubbe states that he has twice had to reoperate for recurrent invagination In the instances of recurrence reported in the literature the cause has usually been found to be a small tumor within the bowel In an edematous bowel following reduction of the invagination small tumors within the intestinal wall may be easily overlooked

**Chronic Intussusception**—Inversion of the bowel does not uniformly eventuate in acute obstruction and strangulation of the telescoped segments Congestion and edema are the factors that produce obstruction in strangulation Occasionally the blood supply of the bowel is not vitiated obstruction is incomplete or absent resulting in chronic intussusception It occurs most frequently in adults and often in the presence of a tumor or Meckel's diverticulum which serves as the entering wedge for the development of the invagination In 129 such cases collected by Goodhall (1910) from the literature the condition had existed for more than six months in 32 patients and for more than one year in 11

Symptoms of chronic intussusception are usually atypical. In the majority of instances however the onset is abrupt as in acute intussusception.

#### F ERRORS (OTHER THAN CONGENITAL STENOSIS) IN DEVELOPMENT OF THE INTESTINE GIVING RISE TO INTES- TINAL OBSTRUCTION

(See Section on Congenital Anomalies of the Intestine)

## II INTESTINAL OBSTRUCTION DUE TO NERVOUS IMBALANCE

### A INHIBITION (PARALYTIC) ILEUS

*Etiology*—This type of obstruction is most often seen in peritonitis. Its occurrence in mild grades following intra-abdominal operations of practically every sort is well known. Incident to each operative intervention in the peritoneal cavity a moderate paretic condition of the bowel obtains in which distention and difficulty in expelling gas are present. As the paresis begins to diminish dilated loops contract down on their gaseous and fluid content and gas pains are felt. Reflex inhibition ileus is observed following strangulation of the omentum in renal attacks not uncommonly and less frequently in gallbladder colic following torsion of an ovarian cyst or strangulation of the spermatic cord. Reflex dilatation of the intestine with markedly impaired motor power may obtain. Fractured ribs, injuries of the spinal column, blunt trauma to the abdomen, embolism and thrombosis of the mesenteric vessels, retroperitoneal infection and hemorrhage as well as infectious fevers such as meningitis, pneumonia and typhoid fever may give rise to a severe grade of meteorism. Following the ingestion of raw beans or oats inhibitive ileus has been known to develop.

*Pathology*—The term paralytic ileus is badly chosen for the intestinal wall is not paralyzed; on the contrary its activity appears to be inhibited by an overactive sympathetic nervous system. After the influence of the sympathetics has been shunted out by blocking of the splanchnic nerves or by spinal anesthesia the paretic intestine of paralytic ileus can be made to contract. The

entire intestine is usually dilated in inhibitive ileus. Occasionally collections of fluid and gas concern only certain segments of the bowel. The intestinal wall is often thinned out and it is frequently somewhat dusky in appearance because of the slight venostasis occasioned by the dilatation of the bowel and the pressure on the mesenteric veins returning from over the surface of the bowel. Perforation and gangrene however rarely occur despite enormous distention.

*Clinical Features*—Extreme meteorism dominates the picture and may be great enough to embarrass the respiration. The patient does not complain of colicky pain as does the patient with mechanical obstruction. On auscultation the abdomen is relatively silent, only feeble noises being heard. Usually no gurgling or splashing sounds are audible. Tenderness over the abdomen is usually noted, very little or no pain may be complained of. Despite the obviously dangerous condition of the patient he frequently has no conception of the gravity of his illness and euphoria is commonly observed. A scout film of the abdomen shows gaseous distention usually of the entire bowel.

*Prognosis*—The outlook depends largely on the cause. In peritonitis the outlook is always poor for the patient still must conquer the infection despite subsidence of the distention. Inhibitive (paralytic) ileus of reflex origin usually responds well to treatment.

*Treatment* of paralytic ileus presents two extreme difficulties: (1) to cope successfully with the cause and (2) to treat an inactive bowel. In inhibition ileus occasioned by retroperitoneal collections of exudate or following torsion of an ovary or testis correction of the underlying process usually brings about an amelioration of the distention. Hot stupes to the abdomen, atropine, pituitary extract, pilocarpine, physostigmine and choline have all been advocated for the treatment of distention observed during the course of inhibitive ileus. Enemas may give temporary relief and may cause the evacuation of some gas but are usually of no great value. Enterostomy has been extolled by a number of authors but the experience of most surgeons is that enterostomy rarely

succeeds in emptying many loops of bowel. Spinal anesthesia sometimes gives temporary relief. Intravenous injections of hypertonic saline solution (0.16 to 0.93 Gm per kilo of body weight) frequently bring about vigorous intestinal contraction. On the whole, however, suction applied to an intubing duodenal tube is found to be more successful. The Miller Abbott type of duodenal tube is of particular value in cases of distention of this type. Nevertheless when the distention has become established occasionally suction proves of little value. In instances in which the development of inhibitive ileus is anticipated improved results may be obtained by the early institution of suction siphonage by means of a nasal catheter before distention has developed.

### B SPASTIC ILEUS (DYNAMIC OBSTRUCTION)

*Etiology*—In this condition spastic contraction of a segment of the intestine obtains in contrast to its relaxation which is observed in inhibitive ileus. The late J. B. Murphy's (1896) initial description of the condition concerned a patient with lead colic in whom adequate cause for such unusual intestinal contractions was apparent. Most instances however concern the colon. Trauma, neurasthenia and hysteria and intrinsic factors operating from within the bowel such as foreign bodies, worms, ulcers or irritating substances have been observed to give rise to the condition. Spastic ileus has been known to occur in renal colic and in infectious fevers. A gallstone occasionally causes obstruction when its diameter is such that it could not mechanically obstruct the lumen in such instances the spastic element has been assumed to play a role. The actual mechanism by which this variety of obstruction occurs is not well understood. Occasionally patients are seen with a mixture of the inhibitive and spastic types of nervous imbalance.

*Pathology*—The involved segment is usually contracted and its wall thickened. The collapsed segment may be short or long; ringlike constrictions are not infrequent. The bowel above the spastic area dilates and exhibits gaseous and fluid accumulations. No perforations have been noted in fatal cases.

*Clinical Features*—The picture of this type of obstruction simulates closely that of mechanical obstruction. In patients who have been previously operated on, confusion with adhesive ileus is likely to occur. In the experience of the writer, adhesive ileus almost invariably concerns the small intestine, whereas in spastic ileus the colon is most frequently distended. Many of these patients are definitely neurotic, and in a

non-obstructive phase the nature of their complaint is usually recognized.

*Prognosis*—With proper recognition and treatment the outlook, as far as the acute attack is concerned, is good. Recurrence, however, is not infrequent.

*Treatment*—If the ailment can be correctly identified, the non-operative course is usually the wiser. Temporary employment of suction siphonage by means of a nasal catheter together with tidal irrigation and suction applied to an intubing rectal tube usually results in abatement of symptoms.

## III VASCULAR OBSTRUCTION

### A INTESTINAL OBSTRUCTION DUE TO MESAENTERIC THROMBOSIS AND EMBOLISM

*Etiology*—Trotter (1915) collected in monographic form the reports of 360 cases of mesenteric thrombosis and embolism. Arterial occlusion was found to contribute 60 per cent of the total thrombosis of the mesenteric vessels, the remaining 40 per cent in a few smaller series venous thrombosis has been observed to occur more frequently than embolism of the mesenteric arteries. The superior mesenteric artery is more frequently concerned in embolism than is the inferior, partially because of its earlier exit from the aorta but largely because of its more direct continuation from the abdominal aorta. Embolism of the inferior mesenteric artery may obtain and infarction of the bowel may fail to occur significant of the free anastomosis which occurs between the end vessels of the systemic arteries and the inferior mesenteric branches. Vegetations on the valves on the left side of the heart are the usual etiologic agents in embolism of the mesenteric arteries. Embolism is more frequent than thrombosis of the artery. Mesenteric venous thrombosis is usually associated with infection in abdominal organs that are tributary to the portal vein. Appendicitis, pelvic infections and strangulation of an external hernia are frequent precursors of the condition. Thrombosis or embolism of the mesenteric vessels rarely affects children; adults between the ages of thirty and seventy are most frequently attacked.

*Pathology*—Distention of the involved segment with accumulation of bloody fluid in the peritoneal cavity as well as within the segment is the rule. Demarcation of the involved intestine from the normal is usually sharp though in some instances the margins of healthy and diseased intestine are poorly defined. When obliteration of the mesenteric artery occurs slowly intestinal infarction may not result. Chiene (1868) has placed on record the fatal case in a woman aged sixty-five. Autopsy was performed in the Anatomical Laboratories at Edinburgh and it was found that the abdominal aorta was completely occluded by an aneurysm that extended as far down as the bifurcation. The branches of the mesenteric arteries were filled by injection through the superior hemorrhoidal artery which was fully as large as the femoral artery.

**Clinical Features**—It is an interesting fact that in many cases of mesenteric thrombosis there is a fairly mild course more than a week elapsing frequently before the existence of a serious lesion is suspected. Only a few patients apparently exhibit prominently the phenomena of mechanical obstruction. The usual manifestations of this disease are the sudden onset of severe abdominal pain, vomiting and diarrhea. Stools and vomitus occasionally contain blood. Shock may be present. Distention of the abdomen is progressive though not extreme. Abdominal tumors have been palpated in about 5 per cent of cases. If arterial occlusion is present the disease tends to be more acute than when due to venous obstruction. Visible peristalsis is rarely observed. Infarction of a portion of the intestine is frequently complicated by peritonitis and its sequelae. Knowledge of the previous existence of a probable source for an embolus or adequate cause of mesenteric venous thrombosis should be present before the preoperative diagnosis of vascular occlusion can be entertained.

**Prognosis**—Of necessity the outlook is exceedingly poor. Nevertheless in a number of cases recovery has followed successful excision of the devitalized portion of the intestine.

**Treatment**—Early operation and excision of the involved segment is indicated. There are a number of reports of cases in the literature in which the abdomen has been opened and the entire small intestine found to be cyanosed, yet the patient has recovered without further operative procedure.

Excision followed by primary anastomosis is the operation of choice when it is feasible because of the length of intestine usually concerned. Exteriorization should be reserved for those cases in which the length of the devitalized segment is not excessive.

Excision of one third of the small intestine in adults is usually tolerated without untoward effect. Infants and children do not tolerate extensive resection as well as adults. In a number of cases in which the resected portion of the small intestine exceeded 6 feet in length, Moynihan (1906) found that whereas usually the patients get in well many subsequently died of a marantic condition. The most extensive successful resection on record is that of Jerrault (1909) who excised 19 feet (569 cm.) of the small intestine for gangrene

caused by embolism of the superior mesenteric. This patient was subsequently operated on by burn for intestinal obstruction due to a thrombosis of the small intestine. The patient operated on by Doerfler appears to have survived with a remaining port small intestine so short that Doerfler was prompted to ask whether man may live without the small intestine. He resected 18 feet 8 inches (560 cm.) of the intestine for volvulus of the entire small bowels. The patient survived for thirty hours standing. Below the duodenojejunal junction there remained 12 cm. and 20 cm. above cecum. Six and a half years later when Doerfler has reported the patient was in good health and ate of food only at regular mealtimes and ate in enormous amounts. His bowels moved normally each day. Some time immediately following the operation ever the patient was distressed by gas and by movements every four to six hours at that time he it necessary to eat something every few hours.

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# ANOMALIES, INJURIES AND FOREIGN BODIES OF THE COLON; DIVERTICULITIS; FISTULA, AND ULCERATIVE COLITIS

## MEGACOLON; CONGENITAL IDIOPATHIC DILATATION OF THE COLON, HIRSCHSPRUNG'S DISEASE (1886)

The classification of megacolon includes the primary or idiopathic megacolon (Hirschsprung's disease), in which an etiologic factor cannot be found, and the secondary or acquired megacolon, in which demonstrable or questionable etiologic factors are present.

**Etiology.**—Except in the cases in which definite anatomical obstruction is demonstrable in the bowel the cause of megacolon is unknown. The most important hypotheses relative to the etiology are based on mechanical, inflammatory, hypernutritive congenital, neuropathic and other causes. The inflammatory theory may be discarded as untenable, there appears to be only one proponent of the theory of hypernutrition, the theory of congenital origin though not explaining the ultimate cause, is supported by several facts, although there may not as yet be any anatomic evidence for the neuropathic theory, in recent years a gradual tendency has been noted toward its general acceptance, as evidenced by the favorable response to sympathetic ramisection and ramisection.

Idiopathic megacolon is most common in infancy or early childhood. The symptoms are present from birth or early life. In a few cases symptoms do not manifest themselves until adult life, and rarely not until advanced age. More males than females are affected, the proportion being 3.5:1. A familial tendency is present, and a considerable number of cases have been observed in mentally defective persons, other congenital defects being frequently associated.

**Pathology.**—The morbid anatomy of the bowel is enlargement of the affected portion usually with hypertrophy of the walls and occasionally with elongation. The sigmoid flexure is the region most commonly affected, and the entire large intestine, exclusive of the rectum, is the next most common. The sigmoid flexure, according to Finney, is involved in the process either alone

or with other portions of the colon in 80 per cent of the cases.

**Symptomatology.**—The two cardinal symptoms are obstinate constipation and distention of the abdomen. These symptoms appear in typical cases during the first days or weeks of life and persist with brief periods of remission throughout life. In some cases pronounced symptoms do not appear until later in childhood or in adult life. The most striking feature is the extraordinary infrequency of bowel movements in the absence of the features of acute obstruction: the patient not defecating perhaps for a period of three or four weeks. Bowel movements are generally induced with great difficulty, large doses of drastic cathartics may be taken without effect. Stools are often large and inspissated, and the odor is often rancid. At intervals there may be diarrhea or vomiting. Abdominal distention, which may be present at birth to such degree as to interfere with delivery, is usually noted within the first few days or weeks of life. It is caused by distention of the colon with feces and gas and varies indirectly with the activity of the bowels. It may be uniform and general or it may be localized corresponding to the position or content of the affected portion of the bowel. Secondary symptoms (often associated) include a wide costal angle, thin abdominal wall, distasis recti hernia, distention of the superficial abdominal vessels, displacement of the thoracic viscera, dyspnea, cardiac embarrassment, audible borborygmus, visible sluggish peristalsis, edema of the extremities and impaired nutrition.

**Diagnosis.**—The diagnosis of megacolon may be made on a history of unusually obstinate constipation and abdominal distention in a patient apparently in good health. It may be confirmed by fluoroscopic examination with the use of an opaque enema. Megacolon must be distinguished from acute intestinal obstruction, tuberculous peritonitis, ovarian cyst and rickets.

**Prognosis.**—The prognosis is uncertain. In infants malnutrition and acute infections are the chief complications. In mild cases acute toxic or obstructive symptoms may supervene and cause death. Perforation of the bowel and death from pulmonary embolism have been reported.

**Treatment**—While the results of medical treatment for megacolon are not good most patients can be carried along without operation. If the disease is limited to the left colon resection of the left half of the transverse colon, splenic flexure, descending colon and sigmoid can be carried out by a Mikulicz type of resection thus fixing the joined barrel to the abdominal wall. This is followed by subsequent closure of the colostomy as a second stage. Operations employing plication or fixation of the colon without resection have been unsatisfactory. The emergency relief of severe obstruction by means of colostomy may be necessary. Lumbar sympathectomy with denervation of the inferior mesenteric artery and removal of the presacral nerve offers some chance of improvement or relief but has been followed by recurrences in some cases. (See the section on the Autonomic Nervous System.) Anastomosis of the ileum to the rectosigmoid with colectomy has yielded the best results of all operative methods.

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#### VOLVULUS OF THE COLON

Volvulus is an obstruction of the intestine due to the twisting of the bowel on its axis. According to Vaughan more than half of the cases of volvulus occur at the sigmoid flexure; fewer at the cecum and fewest in the small intestine. Volvulus of the sigmoid flexure is a fairly usual condition in eastern Europe and is associated with adult life. The average age is forty five years. It is more common in males than females (ratio of 4 to 1) although between the first and twentieth year the disease occurs to approximately equal extent in the two sexes. It is suggested that the explanation for this may be found in the lesser capacity of the abdominal cavity and the firmness of the abdominal coverings rendering it much more difficult for spontaneous reposition to take place in men. Strong and muscular men are

most frequently the victims of this disease. In women because of a wider pelvis and relaxation of the abdominal muscles as a result of frequent pregnancies there is more room in the abdominal cavity and thus greater possibility of spontaneous reposition.

The length of the flexure and the narrowness of the sigmoid mesocolon are emphasized as important factors in the development of the condition. It having been definitely established that a long flexure is a predisposing factor of great importance.

The most common predisposing cause of volvulus is the presence of structural changes mostly bands or adhesions either of congenital origin or formed by previous peritonitis. Volvulus has also been reported as due to old scar formation and chronic mesenteritis. Former operations with resulting bands and adhesions, mesenteric cysts, habitual constipation and chronic intestinal stasis with traction on the mesentery also predispose to this condition. Another cause is thought to be non rotation of the common mesentery and large and small intestine during embryologic development. It has also been suggested that volvulus is often due to disordered peristaltic action. A high percentage of volvulus in patients with intestinal obstruction is reported in predominantly vegetarian races, the bulky diet probably resulting in intestinal atony or chronic distention thus contributing to twisting of the bowel. (For symptoms, diagnosis and treatment of volvulus see section on Intestinal Obstruction.)

#### INJURIES AND FOREIGN BODIES IN THE COLON AND RECTUM

**Etiology.**—The conformations of the rectum and sigmoid flexure render them peculiarly liable to the arrest and retention of foreign bodies which can reach these cavities (1) by being swallowed and passed through the intestinal canal; (2) by their development in the upper bowel and passage through it to the colon, sigmoid and rectum; (3) by introduction through the anus and (4) by traveling from a neighboring organ through an ulcerated opening in the separating structures. All kinds of objects have been found in the colon particularly in the rectum. The rectal objects are not caught more often in the angulations of



the sigmoid valves of the rectum or sphincter muscles is that they are covered with fecal matter and thus pass without causing injury.

Several factors anatomical physiologic and pathologic contribute to the lodgment of foreign bodies in the pelvic bowel. The pouches or sacculi of the colon disappear as soon as the bowel enters the pelvis and the lumen of the intestine is encroached on by the rectal valves which retard the free movement of the fecal bolus. At this level the lumen further decreases and the mucous membrane is thrown into numerous longitudinal folds which terminate near the anus in the crypts of Morgagni where small bodies are frequently caught. The sphincters also completely close the lower anal canal.

Articles of every conceivable size shape and composition have been swallowed and passed safely through the intestinal tract producing no symptoms. The patient usually knows that he has swallowed some object although this may not be so in children or the insane. When large bodies are swallowed the patient is aware of the fact and usually seeks medical advice immediately. The body if comparatively smooth and of such size as to be swallowed without difficulty may be expected to pass through the intestinal canal at least as far as the sigmoid flexure or the rectum. The length of time required for passage to the rectum is very indefinite. Fruit seeds coins buttons pins and false teeth frequently pass through the digestive tract to the sigmoid or rectum where they may be caught.

Fecal concretions may develop in all the portions of the intestine where the movement of the fecal current is retarded at the cecum the hepatic splenic and sigmoid flexures and in the ampulla of the rectum.

Foreign bodies are sometimes introduced intentionally through the anus into the rectum for relief of certain symptoms to excite sexual passion for purposes of concealment or by accident. The patient does not seek a physician until he is compelled to do so because of the great pain and suffering which result.

Instances in which foreign bodies have gained entrance to the rectum from adjacent organs are extremely rare. It is unusual for them to be introduced into the rec-

tum by simple accidents such as a fall on a pointed stick or on a fence paling which may break off and remain within.

**Symptomatology**—The symptoms are subjective and objective and vary considerably according to the location of the foreign body and the extent of the damage. The patient usually presents symptoms suggestive of common rectal ailments such as constipation diarrhea hemorrhage or immediately following stool passage of mucus tenesmus and pain. If the foreign body has been swallowed or introduced into the rectum legitimately the patient gives a frank history and a correct diagnosis is easily made. The pain depends on the shape of the object. A round smooth body causes much less suffering than an irregular one with ragged edges or sharp points. If the mucous membrane of the rectum is penetrated torn or ulcerated the pain is more or less constant particularly if the body is lodged in the lower rectum. If the object is large and has smooth rounded surfaces the pain may not be acute but rather of a dull heavy aching character increased on movement. Spasm of the sphincter and levator ani muscles is often present. Constipation and sometimes obstruction may occur. Genitourinary complications may be so marked as to cause suspicion that these organs are the seat of the disturbance. Dysuria anuria cystitis and pains referred to the testicles scrotum and along the crural nerves are all frequent symptoms. These are probably the result of pressure on the urinary tract by the foreign body or are due to reflex action. If a foreign body has been lodged in the rectum for some time there may be considerable constitutional reaction. If the object has been introduced through the anus there may be some injury.

**Diagnosis**—The diagnosis is in some cases quite difficult to determine. It may be made by digital examination seeing the object through a proctoscope or by means of the fluoroscope or of roentgenograms. Careful digital exploration of the rectum is advised routinely.

**Prognosis**—In the majority of cases a foreign body in the rectum is removed successfully. However it may not always be successfully removed and death may result from peritonitis shock or hemorrhage.

**Treatment**—Treatment depends to a great extent on the location and nature of the object. If found low down in the anus or in the rectum and not too large it can usually be extracted from below. As foreign bodies are usually introduced into the rectum with the small end first and the sphincter is thus gradually dilated until the body slips from the hand and the sphincter closes behind it the removal is generally more difficult than the introduction because the large end must be grasped and dragged down first. The spasm of the sphincter consequent on the traumatism increases the difficulty of withdrawal. The object may be grasped with forceps and removed. Pressure or manipulation may cause it to slip further into the sigmoid flexure and if it is sharp it may perforate the intestine and cause peritonitis. First the bladder should be emptied. It is usually necessary to anesthetize the patient and dilate the sphincter before any attempt at removal is made. The parts should be thoroughly irrigated so as to remove as far as possible any surface contamination that might predispose to infection. The field should be thoroughly anointed by injecting oil into the rectum and the finger should be lubricated to facilitate slipping the object through the constricted area. It is better to cover sharp or jagged edges with gauze.

When a foreign body is lodged so high in the rectum or sigmoid that it cannot be extracted through the anus there is no recourse other than laparotomy. The mortality from this method of relief is high.

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#### DISEASES OF THE APPENDICES EPIPLOICAE

Appendices epiploicae are defined as localized pedunculated overgrowths of subserous fat directly continuous with the fat in the layers of the mesentery. They are formed by a reduplication of the peritoneum which enmeshes a variable amount of fatty tissue between its layers and consist of small processes or pouches which are confined to the large intestine none appearing on the rectum.

The number of appendices epiploicae pres-

ent may vary widely an adult usually possessing about 100. While arranged along the whole course of the large intestine they are most numerous in the transverse and pelvic colon (the cecum as well as the vermiform appendix sometimes giving origin to them) but there are none in the rectum. The appendices are arranged in two rows one in relation to the anterior muscular band the other to the posterior band.

The lesions incident to the appendices epiploicae may be divided into the following groups: 1. Mechanical interference with the blood supply by direct pressure or torsion. (a) Within the abdominal cavity or in a hernial sac. (b) formation of foreign bodies within the peritoneal cavity or in a hernial sac as a result of interference with the blood supply, (c) torsion associated with and secondary to other inflammatory lesions of the abdominal cavity. 2. Infection of the appendices epiploicae. These are incident to or associated with interference with the blood supply or to lesions of the corresponding segment of intestinal wall (diverticulitis). 3. Adhesions of the appendices epiploicae causing intestinal obstruction.

Foreign bodies in the peritoneal cavity the end result of torsion of the appendices epiploicae give no definite symptomatology unless infected then the symptom and signs of peritonitis will predominate. They may cause vague abdominal complaints simulating those of gallbladder or other disease. Sudden torsion of the appendices with or without infection results in sudden sharp abdominal pain not necessarily limited to the seat of torsion. The pain may be referred to the right side of the abdomen when the torsion actually exists in an appendage of the sigmoid flexure. Vomiting, tenderness and rigidity (in short the picture of an acute surgical condition which is mistaken for acute appendicitis or diverticulitis) supervene. The treatment is surgical.

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#### DIVERTICULOSIS AND DIVERTICULITIS

**Definition.**—When one or more pouches are found in the large intestine the term *diverticulosis* is applied. Diverticula may

occur throughout the gastrointestinal tract but are most common in the sigmoid colon. When inflammation occurs in one of the pouches the term *diverticulitis* is applied. Diverticuli of the large intestine are found in 3 per cent of the population and in 5 per cent of persons over forty years of age. They are usually multiple and may possess all of the coats of the large intestine (true diverticula) or have only mucosal and serosal coats (false diverticula). If the opening of the sac into the intestine is large there will rarely be associated symptoms. Inflammation may follow inability to empty the diverticulum of its contents. Diverticulitis is more likely to occur in false diverticula because of the lack of a muscular coat for emptying it as well as in those with a small opening into the colon.

**Etiology.**—Most diverticula have a congenital origin. They may later increase in size and number although there is probably an inherent weakness in the wall with constipation being the most important developing factor. They are most apt to occur in sedentary and obese individuals.

**Symptoms.**—Many patients with diverticulosis have no symptoms or have symptoms that are so minimal that medical advice is not sought. Vague abdominal distress, chronic indigestion, constipation and shifting abdominal pain may be present. On the other hand, diverticulitis is always accompanied by symptoms of varying severity. Abdominal pain usually occurring in the left lower quadrant or over the immediate site of the diverticulitis, fever, leukocytosis and abdominal tenderness are the rule. A mass is usually present. Mild and intermittent bleeding of the bowel occurs in 20 per cent of cases. Obstructive symptoms are common.

**Treatment.**—All patients with diverticulosis accompanied by symptoms should be treated by dietary and medical means. Like wise all cases of acute diverticulitis should be treated by rest and diet. The use of sulfonamides or penicillin is hardly justified. Operative treatment should be limited to those with recurrent attacks, to those with abscess formation or to those with obstructive symptoms. Operative treatment for possible abscess should be delayed until fluctuation can be felt since in most cases the

abscess will perforate into the bowel lumen and spontaneous cure result. When obstruction persists a proximal colostomy should be performed preferably at some distance proximal to the infection. For the typical diverticulitis of the sigmoid with obstruction a double barreled colostomy of the transverse colon of the Mikulicz type is the procedure of choice. With diversion of the fecal stream subsidence of the inflammatory process will usually result in an adequate lumen of the bowel and this type of colostomy can readily be closed extraperitoneally. If symptoms persist in spite of proximal colostomy, resection of the area involved should be carried out with end to end anastomosis before closure of the proximal colostomy. No resection for diverticulitis should be done as a one stage procedure because of the high mortality which results from peritonitis. The presence of a sigmoidal vesical fistula demands proximal colostomy followed in six to twelve months by resection with closure of the bladder opening.

In many cases it will be difficult to exclude carcinoma coincidental with diverticulitis. The differential diagnosis can usually be established by proctoscopic examination or by the barium enema or double contrast air enema. If after these examinations doubt still exists as to the presence of an accompanying malignant growth, resection should be carried out.

The mortality for operations for diverticulitis in the past has varied from 20 to 50 per cent but this can be materially lowered if proximal colostomy, two stage operations and delayed operative treatment are carried out.

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#### GRANULOMATOUS DISEASES OF THE COLON

Granulomas of the colon are a localized inflammatory process and may be of specific or non specific etiology. Since reduc-

tion in the incidence of tuberculosis of the intestine they are rarely encountered

**Etiology**—The following conditions are included in this group (1) tuberculosis (2) non specific cicatrizing regional colitis (3) gumma (4) actinomycosis blastomycosis and hydatid disease and (5) lymphogranuloma

**Tuberculosis**—Until recent years tuberculosis of the cecum was more frequently encountered. In most cases the process was limited to the right colon at times including the first half of the transverse colon. The ingestion of the tubercle bacilli in the presence of pulmonary tuberculosis or from the milk of infected cattle could usually be shown to be the cause. Intestinal tuberculosis of a mild type could usually be controlled medically. A short circuiting operation joining the ileum to the transverse colon when obstruction is present usually gives little relief. Resection of the entire area of involvement including as much mesentery and glands as possible is the procedure of choice.

**Non Specific Cicatrizing Regional Colitis**—This condition in the colon is similar to that occurring in other portions of the gastrointestinal tract notably the distal ileum. The symptoms are the same as for obstructing carcinoma of the intestine and the condition cannot be differentiated by a barium enema or by an air contrast enema. Resection should be performed in all cases and usually the diagnosis is first considered on examination of the resected specimen. The results of resection are good.

**Lymphogranuloma**—Lymphogranuloma usually is confined to the rectum and obstructive symptoms are present. The condition is differentiated from other granulomatous lesions by means of the Frei test. Multiple sinuses and fistulas are common complications. The obstructive symptoms can be relieved by proximal colostomy in the sigmoid colon but this does not do away with the rectal symptoms including tenesmus and discharge as well as the secondary effects of the infection. Abdominoperineal resection has yielded the best results in these cases.

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#### COLONIC FISTULAS

A colonic fistula is an abnormal channel or communication between the colon and a hollow viscus (internal fistula) or between the colon and the surface of the body (external fistula). Fistulas may be congenital or acquired (pathologic traumatic or post operative). Most colonic fistulas are post operative following drainage of an abscess or direct injury to the colon during operation or caused by infection or leakage at the suture line following resection. A spontaneous fistula as a result of an inflammatory process may occur from ulcerative colitis, diverticulitis, jejunal ulceration following gastroenterostomy, regional enteritis or colitis, tuberculosis, actinomycosis or lymphogranuloma.

**Pathology**—Whether internal or external the fistula is rarely completely lined with mucosa or skin. It has a thick wall with diffuse inflammation and is usually adherent to surrounding structures. A spontaneous fistula shows the characteristic findings of the disease causing it.

**Symptoms**—The most characteristic symptom is the discharge of fecal material with pus and blood. A patient with an internal fistula in the proximal colon may have few bowel symptoms. A patient with a fistula in the distal colon and rectum has the bowel symptoms that are present with any organic large bowel lesion. In cases of multiple fistulas and those associated with intraperitoneal infection, intermittent fever, weight loss, malnutrition and anemia are found.

**Diagnosis**—An external fistula is at once evident. Its extent can be demonstrated in roentgenographic films after injection of an opaque medium such as barium diiodate or lipidol. An internal fistula can usually be shown with the barium enema or by gastrointestinal series. A fistula of a specific type can be differentiated by the examination of the discharge or by biopsy of the tract.

**Treatment**—Operation should be delayed for three to six months until time elapses for possible spontaneous healing. Furthermore, this interval permits subsidence of the inflammation about the tract so that operative removal is facilitated. Complete excision of the fistula is the procedure of choice and can be accomplished by entering the abdomen at a site removed from the

fistula in order to identify its extent. The incision can then enclose the fistula, followed by excision and closure of the bowel, but in many cases resection is required. At times a two stage operation is advisable, with diversion of the fecal stream by sidetracking anastomosis or by means of a proximal stoma followed by later closure or excision of the fistula.

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#### ULCERATIVE COLITIS

**Definition.**—Ulcerative colitis is a non-specific inflammatory lesion of the colon and

leading to its onset. The enterococcus of *Bargen*, bacillary dysentery, amebic dysentery, a neurogenic factor leading to spasms of the colon, an allergic factor and dietary deficiency may make the colon susceptible to a mixed infection.

**Pathology.**—In 90 per cent of the cases the disease begins in the sigmoid or rectum as a mucosal infection, as evidenced by hyperemia of the mucosa followed by minute hemorrhagic ulcerations which may be confluent. The ulcerations usually begin under the longitudinal band and may be confluent, leading to destruction of the greater portion of the mucosa. Infection spreads through the submucosa to involve all coats of the



Fig 563.—Chronic ulcerative colitis—"lead pipe" colon

rectum, occasionally involving the distal ileum. Other inflammations of the colon of a similar diffuse type due to some specific cause, such as bacillary dysentery, amebic dysentery and the granulomatous lesions, should not be included under this diagnosis.

**Etiology.**—A number of possible causes of this disease have been proposed, with considerable evidence to support them by their proponents, yet none can be considered as a specific causative agent. Until more acceptable evidence has been presented, this must be considered to be a non-specific disease with several possible causative factors, either singly or in combination,

including the muscular and serosal coats. The disease spreads by continuity both along the mucosal surface and through the lymphatics. The muscular coat becomes markedly thickened and the serosa injected. If no remission occurs, the disease continues proximally to involve all of the colon and, in 20 per cent of the cases, the distal ileum. At times the disease is segmental in character, involving only portions of the colon, such as part of the transverse or right colon, or remains confined to the lower sigmoid and rectum. In the course of healing, there is marked contraction, so that in advanced cases the lumen of the bowel may be re-

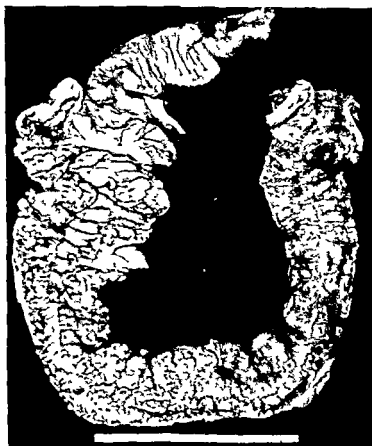


Fig 569—Chronic ulcerative colitis with marked fibrosis and polypoid change



Fig 570—Acute diverticulitis with obstruction. Differentiated from malignant growth by air contrast enema.

duced more than half. In some cases the colon becomes a rigid tube the so called lead pipe colon incapable of contraction or other function. When healing occurs in the milder cases the mucosa may remain red, denuded and granular even in the presence of complete remission. The cicatricial stage of the disease may be accompanied by an abscess, fistula or sinus into other portions of the intestine, bladder, vagina or perineum. Ano-rectal disease is a common manifestation. Pseudopolypoid produced by islands of mucosa between ulcerations is common in the late stages of the disease.

**Symptoms**—The symptoms of ulcerative colitis can be grouped into general and local symptoms. The general symptoms are those of any infectious process. Fever, malaise, weakness, prostration, loss of weight, dehydration and anemia are conspicuous. The local symptoms are all bowel symptoms. Diarrhea, tenesmus, passage of blood, mucus and pus, generalized abdominal and rectal pain focus attention on the large intestine as the site of the lesion.

**Diagnosis**—The disease is confirmed in the presence of the aforementioned symptoms on proctoscopic examination. The diffuse character of the mucosal involvement, bleeding from the mucosa on manipulation of the proctoscope or by swabbing cannot be readily confused with that of other inflammatory diseases of the lower large intestine. The Craig complement fixation test for amebic dysentery, the stained smear and cultures for bacillary dysentery and examination of the stool for *Endamoeba histolytica* and the tubercle bacillus exclude the various possible causes. The proctoscopic examination may be negative in 10 per cent of the cases when the upper colon is involved in a segmental form. The characteristic appearance of a malignant growth plus biopsy confirmation makes it possible to exclude carcinoma which must be considered as a possible diagnosis in all cases. Malignant growth on the basis of a pre-existing ulcerative colitis is rare, occurring in less than 1 per cent. The barium enema is used to determine the extent of the involvement as well as the stage of the disease. In the presence of ulcerative colitis the lumen of the bowel is decreased, the haustral markings are decreased or absent, motility is decreased and there is

foreshortening of the bowel. In advanced cases in which ulcerative colitis has existed for a long time the length of the colon may be diminished by half.

**Treatment**—Medical treatment should first be tried in all cases of ulcerative colitis both in its acute and in its chronic form. Medical treatment is unsatisfactory because of poor response or recurrence of the disease in approximately 40 per cent of the cases. In 15 per cent of these cases the patient can be continued on medical treatment with some incapacity while 25 per cent will require surgical treatment because of complications of the disease not amenable to medical treatment.

Indications for surgical intervention are as follows: (1) intractability on medical treatment with incapacity persisting for three months or more each year; (2) obstruction of the colon because of cicatricial change; (3) subacute perforation, abscesses, sinuses or fistulas; (4) persisting hemorrhage; (5) infectious arthritis; (6) polypoid change; (7) carcinomatous change.

**Operative Procedures**—In the past surgical treatment has been unsatisfactory either because the wrong operative procedure was employed or because surgical treatment was accepted too late. Appendicectomy, cecostomy and colostomy have been tried and have proved to be useless. Ileostomy or colectomy, either partial or complete, is the operative procedure of choice.

**Ileostomy** should be performed in any acute case where response is not satisfactory within seven days under medical management. It should be employed in all cases of the seven groups previously listed as indications for operation. The ileostomy may necessarily be permanent if sufficient destruction has taken place in the colon. If clinical remission occurs in the presence of ileostomy the colon can be left in. If healing occurs with clinical relief of symptoms and if a satisfactory proctoscopic appearance of the lower bowel and distensibility are present as shown by a barium enema, the ileostomy may be resected and intestinal continuity restored. This is done in approximately 10 per cent of all ileostomy cases. If symptoms persist in spite of ileostomy, then either partial or total colectomy should be performed. Partial colectomy is employed

when the patient has the segmental distribution of the disease and total colectomy, including removal of the distal ileum the entire colon and rectum is performed in all other cases.

The lives of many patients with ulcerative colitis have been lost because ileostomy would not be accepted by the patient or the physician. There may be considerable difficulty in the care of an ileostomy and this has led to reticence in accepting it. Every patient must wear an ileostomy bag since the ileal discharge may be liquid or semi-solid. The ileostomy should project sufficiently above the skin level so that the discharge passes immediately into the bag without contact with the skin. Many preparations such as aluminum or bronze powder, kaolin, fuller's earth, ointments of all types, compound tincture of benzoin and various dyes have been used to protect the skin but these are unnecessary since skin excoriation can be prevented by a properly performed ileostomy and a properly fitted ileostomy bag. Bags of the Davol type with a small aperture, the Travellor or the Koenig-Rutzen are the most satisfactory. The latter can best be fitted three to six months after the performance of ileostomy and is cemented to the skin fitting the ileostomy perfectly; it is changed but twice in twenty-four hours.

**Prognosis**—A patient with an ileostomy even after total colectomy can resume his normal activity that was pursued before the onset of the disease. The mortality of ileostomy varies between 5 and 25 per cent depending on the stage of the disease when it is performed. Partial and total colectomy can be carried out with a mortality under 10 per cent for all stages. There is no difficulty in maintaining a satisfactory state of nutrition on a normal diet.

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REVISED BY RICHARD B. CATTELL.

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### BENIGN POLYPOID TUMORS OF THE LARGE BOWEL

The different types of benign polypoid tumors of the large bowel are (1) adenoma, (2) papilloma or villous tumor, (3) multiple polyposis and (4) inflammatory polypus. The clinical incidence of these tumors is not great but in about 20 per cent of persons over twenty years of age adenomas are found in the colon at autopsy (Lewy).

#### ADENOMA OF THE RECTUM AND COLON

**Pathology**—This type of epithelial tumor is the most common benign neoplasm that is found in the gastrointestinal tract. Adenomas occur most frequently in the colon and rectum but are also found in the esophagus, stomach and small bowel. In the small bowel a pedunculated adenoma is a



Fig. 571.—Photograph of a multiple pedunculated adenoma of the rectum from a man aged twenty-five.\*

frequent cause of intussusception in adult. In the colon adenomas are found in all portions at all ages from childhood to old age. While clinically they are most often found as single tumors at autopsy, if one is found further search will often reveal several others. Adenomas may vary from the size of a grain of wheat to that of a hen's egg. As regards the attachment to the bowel the tumor may be sessile or pedunculated. The larger the adenoma the more frequent is a

\* *Lewis' Practice of Surgery*, W. F. Page Co. Ed. 1st ed.



pedicle formed by traction of the tumor on the mucosa. The pedicle consists of normal mucosa and may become several inches in length thus allowing the tumor a considerable range of excursion in the lumen of the bowel.

Histologically the appearance of these adenomas varies from hyperplasia of the normal intestinal mucosa to marked increase of the glandular elements of the mucosa as evidenced by branching tubules, multiple cell layers and deeply staining nuclei. In the pedunculated adenomas of children the tumor is covered with rather normal intestinal epithelium and the body of the tumor contains a myxomatous connective tissue in which are the cystic enlargements of the

bleeding is slight but noticeable. In childhood adenoma of the rectum is probably the most frequent source of recurrent bleeding from the large bowel. When the adenoma is in the left half of the colon the blood is usually on the outside of the stool because of the solid character of the stool in this location. Conversely when the bleeding tumor is in the transverse colon or right half of the colon the blood is inside of the hard stool or intimately mixed with it. Obviously the brighter and more fluid the blood is the lower in the colon is the bleeding lesion.

In children in whom a pedunculated adenoma is most often found in the rectum the pedicle may become long enough for the tumor to protrude from the anus at stool. It

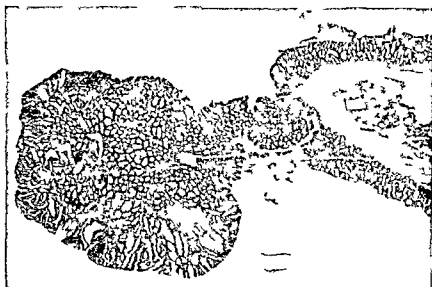


Fig. 573.—Histomicrograph of a pedunculated adenoma of the sigmoid colon in an adult.

glandular structures of the epithelium. This wide variation in the histologic structure of these tumors as well as their rather frequent occurrence in the region of carcinomas of the colon and rectum has definitely raised the question of their relationship to cancer.

**Symptomatology and Diagnosis.**—Clinically considered adenomas of the colon and rectum may be wholly without symptoms. This is particularly true if they are flat and small. However if they become pedunculated and are subjected to more traumatic bleeding occurs and this is the most common symptom noticed by the patient. On occasion the bleeding may be copious and from 4 to 6 ounces may be lost. Usually the

has a characteristic red and slightly lobulated appearance. When adenoma is suspected but no protrusion has occurred digital examination of the rectum may allow the tumor to be palpated and the finger may hook around the pedicle and prolapse the tumor through the anus.

Proctoscopic examination should always be carried out if adenoma of the rectum or colon is suspected if the tumor can be seen the site and character of its attachment to the colon its freedom of movement and the question of ulceration can be determined. It must be remembered that a pedunculated adenoma of the colon can prolapse into the rectum if the pedicle is long also with an air inflation proctoscope a pedunculated

adenoma of the rectum may be blown upward into the colon and therefore not observed.

The site of the adenoma in the large bowel above the rectum can be determined only by fluoroscopic examination of the colon. It may be possible to push an air bubble filling defect up and down in the bowel for a few inches because of the freedom permitted by the pedunculated attachment of the tumor. Thus an air bubble defect must always be present in the same place on repeated examination if a reasonably safe diagnosis is made. It should be emphasized that this filling defect is not due to indentation or malformation of the regular outline of the bowel but is a defect resembling an air bubble within the lumen of the bowel. In some cases it is impossible to find a filling defect and the diagnosis can be established only by exploratory laparotomy after other possible sources of bleeding from the stomach and bowels have been ruled out. It is recognized that bleeding from a carcinoma of the small bowel or Meckel's diverticulum is extremely difficult to diagnosis. The following brief case report will serve as an illustration.

A man aged fifty three who in times past had been treated medically for a duodenal ulcer and had been free of symptoms for several years noticed blood intermittently in the stool. The blood was fluid and sometimes red but often clotted and was on the outside of the stools. Repeated proctoscopic and fluoroscopic examinations failed to reveal the source of the bleeding. As gross bleeding of relatively fresh blood continued an exploratory laparotomy was performed and a pedunculated adenoma about 2 cm. in diameter with a long pedicle of normal mucosa, was palpated in the sigmoid loop. With rubber blade clamps on the bowel above and below the tumor the bowel was opened along the longitudinal muscle band the polyp delivered the pedicle ligated the tumor removed and the bowel closed in layers. No other lesions were found.

**Treatment**—The treatment of an adenoma in the rectum is simple when the pedunculated tumor can be prolapsed through the anus. The pedicle is ligated and the tumor removed. If the tumor is higher but can be seen through a proctoscope it can be grasped with a slender tenaculum and rotated so that the pedicle is visible. The pedicle can then be fulgurated and the adenoma removed. When the adenoma is flat or it is impossible to reach the pedicle, the tumor itself can be fulgurated and re-

moved in one or more stages. The disadvantage of the last procedure is that the tumor cannot be adequately studied histologically. These patients should be examined again after six weeks and the former site of the tumor inspected.

### PAPILLOMA, VILLOUS TUMOR

**Pathology**—A papilloma is a soft sponge-like arborescent tumor which is rather infrequently found in the colon and rectum. Only 30 such tumors have come to the author's service. They occur practically always in adults. The usual symptoms are frequent passage of bloody mucus from the bowel or sudden rather copious hemorrhage. A hemorrhage of a pint or more of blood has been the first symptom in some cases. If present in the rectum the tumor can be palpated as a soft indefinite mass without induration at its point of attachment to the bowel. It can be seen through the proctoscope where it appears as a lobulated arborescent tumor having a flat attachment to the bowel and not infrequently completely surrounding the bowel or attached to an area several inches in length. If the tumor is in the colon it may give a filling defect very much like that of carcinoma and with symptoms of bleeding cannot be clinically distinguished from carcinoma. When the tumor is palpated through the intestinal wall however it feels soft and there is no change of the usual external appearance of the intestinal wall. In some cases the tumor cannot be palpated at all in the splenic flexure though a definite filling defect is seen in the roentgenogram. Not all papillomas are seen when they have attained such size and in the early stage of their growth they may be slender branching stalks. These tumors differ from carcinomas in that they are not indurated or ulcerated and histologically they do not invade the basement membrane or muscular mucosa of the intestinal wall. The cells covering the branching stalks are higher than those of the normal mucosa have many more goblet cells and have deeper staining nuclei. It is concerning this type of tumor and the flat adenomas with cellular changes that the question arises as to whether they are pre-malignant growths. If it is maintained that infiltrating destructive growth is the principal sign of cancer, then multiple-layered

epithelium polymorphous nuclei or branching lobules of epithelium give only a suspicion but no proof that a malignant growth is present. Practically speaking the clinician and the pathologist should have common

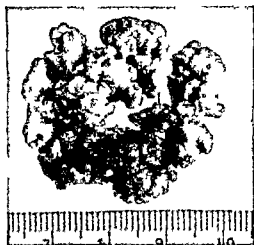


Fig 53—Gross specimen of a papilloma of the rectum in an adult

knowledge about any single case under discussion the appearance of the tumor and its lack or presence of induration or ulceration

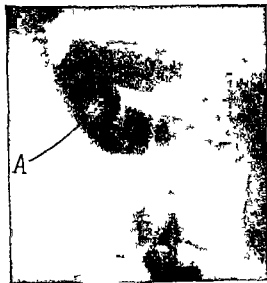


Fig 54—Air bubble filling the defect from a polyp at A

as well as the histologic picture must be fully considered. It is of great importance to submit the whole tumor for histologic examination as the invasion of cells through the basement membrane which is characteristic of cancer can be determined only by an examination of the site of attachment of the

tumor. The examination of small pieces of tumor from the surface of the growth may be misleading and fail entirely to indicate the character of the tumor.

**Treatment**—It is obvious that papillomas of the rectum or colon should by choice be entirely removed for histologic examination. In the rectum this may necessitate splitting the rectum posteriorly after removal of the coccyx so that a complete local removal of the tumor can be accomplished after which the defect may be sutured and the rectum closed by layer stitches. When the papilloma is in the colon a resection of the colon is necessary in order to remove the tumor.

### MULTIPLE POLYPOSIS

In cases of multiple polyposis a rather rare familial condition the entire colon including the rectum is studded with multiple adenomas and small papillomas. All sizes and shapes are present including the flat or



Fig 55—Colon showing multiple polyposis. There were also three separate carcinomas.

pedunculated varieties. The condition has been seen in childhood but is most frequent in young adults. The symptoms are those of frequent passages of blood and mucus passing of small pieces of tumor tissue rapidly developing anemia and cachexia. Proctoscopically the rectum is seen to be studded



Fig 576—Giant section through the bowel showing multiple polyps. The tumors are adenomas and papillomas. At A there is a carcinoma.

with adenomas and fluoroscopically the colon has a characteristic mottled appearance owing to the numerous small filling defects. Carcinoma frequently develops and is often multiple. In the colon shown in the illustration there were three separate carcinomas. It is generally agreed that preliminary ileostomy followed by graded removal of the colon and rectum is advisable if the condition of the patient will permit it. Too often it happens that severe anemia and cachexia or the rapid and extensive development of carcinoma precludes radical treatment.

#### INFLAMMATORY POLYPS OF THE COLON AND RECTUM

In the course of a protracted ulceration of the colon from amebic dysentery or ulcerative colitis small islands of mucosa between the ulcers hypertrophy, become fibrotic and have the gross appearance of adenomas. These growths may reach the size of a walnut and give symptoms of bleeding or partial obstruction of the bowel. One patient who had had a longstanding ulcerative colitis was found to have several polyps of this type in the rectum and sigmoid which had been present for ten years. In another patient with ulcerative colitis a small polyp developed and when it was removed through the proctoscope it was found to be malignant in structure. In some instances stalk like papillomas and flat adenomas develop in a rectum which is the seat of a chronic inflammation. In one such patient a colostomy was performed because of severe and uncontrollable bleeding from a group of such papillomas which appeared benign on histologic examination. After the

colostomy had been established the tumors in the rectum disappeared. The meaning of this evidence is not entirely clear but indicates that inflammation may produce lesions which resemble in detail the structures which are called adenomas or papillomas and which are regarded as tumor formation.

VERNON C. DAVID

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#### CARCINOMA OF THE COLON

Carcinoma is the most frequently encountered tumor of the colon. The apparent increase in its incidence together with cancer in general is very probably due to two factors: first, that a larger number of cancers are recognized than formerly because of modern means of diagnosis; and second, that cancer is chiefly a disease of middle and later life. The average life of man which was formerly forty-two years has been increased during the twentieth century to fifty-eight years so that a greater number of people are reaching the so-called cancer age. In other words, the supposed frequency of the disease is a credit to improved methods of diagnosis and prolongation of the lifetime of man.

Of the entire intestinal tract less than 1 per cent of carcinomas invade the small bowel. The two mobile terminal segments of the colon, the cecum and the sigmoid, are most frequently involved. In a large series of cases which the authors have studied approximately 36 per cent of the growths were located in the colon and 64 per cent in the rectum and rectosigmoid.

**Etiology.**—Carcinoma of the colon may occur at any age, and although it is usually found in the fifth and sixth decades, it is not uncommon to find it in patients between the ages of twenty and thirty. Males are more frequently affected than females, in the proportion of about 2 to 1.

The origin of carcinoma of the colon, like carcinoma elsewhere, remains obscure, although some progress has been made in respect to its predisposing and contributing causes. Bardenheuer and later Quénu and Landel were the first to bring forward his

theory in which the association of the polyps with carcinoma was fairly proved to be more than accidental. In the series of 50 cases of polyposis reviewed by Doering, there were 37 deaths, of which 31 were from carcinoma.

**Pathology.**—Carcinomas of the colon may be conveniently classified, according to their gross and microscopic anatomy, as (1) soft medullary adenocarcinoma, (2) scirrhous or fibrocarcinoma and (3) mucoid or colloid adenocarcinoma. The different types are responsible for the marked varia-

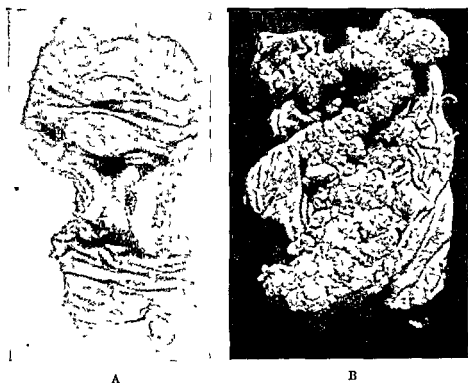


Fig. 577—A, Resected specimen of the splenic flexure of the colon. Note the dilatation and hypertrophy proximal to the annular carcinoma. B, Resected specimen of a colloid carcinoma of the ascending colon; a bulky ulcerating growth.

tologic evidence of the malignant transformation of adenomatous cells. Hauser, Kraske, Verse and more recently FitzGibbon and Rankin, and many others have since reported numerous instances of carcinomatous changes in colonic polyps. Proof is lacking that all carcinomas of the large intestine originate in polyps, but there is considerable evidence to support the belief that most of them arise in just such a manner. FitzGibbon and Rankin reported 13 cases in which these changes were definitely demonstrated, and at least 140 cases have been re-

ported in symptoms as well as the roentgenologic evidence. In the right half of the colon, large, bulky ulcerating lesions, often covered with stubby protuberances like granulation tissue (Fig. 577, A), occur usually on the lateral wall of the colon and produce ulcerating surfaces for absorption but do not tend to produce obstruction, because of (1) the liquid nature of the fecal current at this point, (2) the lack of tendency to encircle the bowel, the lumen of which is greater here than elsewhere in its course, and (3) the likelihood that the growth will go on to

penetration perforation or the formation of abscess. On the other hand in the distal segment of the large bowel carcinoma usually originates close to the mesenteric border and spreads laterally diminishing the size of the lumen and consequently producing chronic subacute and even acute obstruction (Fig 577 B). One may however occasionally encounter a polypoid lesion.

Multiple primary carcinomas of the colon may occur and although they are not often recognized the possibility of such multiplicity of lesions should be kept in mind since it has a significant bearing on prognosis. Birgen and Rankin have reported 16 such conditions in the large intestine. Volvulus and intussusception occur quite frequently as complications of carcinoma of the colon.

Approximately 5 per cent of carcinomas of the colon and rectum are of the mucoid type. Rankin and Chumley reported 158 operative cases of which number 85 (53.8 per cent) occurred in the colon and 73 (46.2 per cent) in the rectum. This histogenesis of mucoid carcinoma is uncertain although many pathologists regard it as a degenerative process. This type of malignant lesion although slow growing is in the end more malignant from the standpoint of ultimate cure than the other types of carcinoma of the colon. Its tendency to recurrence once the regional lymphatic vessels are invaded is most marked.

Eventually regardless of pathologic type ulceration and secondary infection develop. The infection is at first localized but may terminate in spreading suppuration, fistulous tracts or peritonitis. Obstructing carcinomas may produce dilatation and hypertrophy of the intestine above the growth (Fig 577 B). Instead of hypertrophy the intestinal wall may be markedly attenuated above the growth and the mucosa may present a moth eaten appearance because of innumerable small ulcers.

Metastasis in carcinoma of the colon as a rule occurs later than carcinoma of any other portion of the gastrointestinal tract. The lymphatic vessels gauge the extensiveness of the lesion and their invasion influences the prognosis considerably. However distant metastasis even to the liver has been noted although the lymph nodes were not involved. The lymphatic structures of

the cecum and appendix according to Poirier and Cuneo are more extensively developed than those of the other segments of the large intestine yet metastasis from the cecum is among the slowest of any segment of the large bowel. It would seem therefore that rich lymphatic supply is a defensive mechanism and favorable to prognosis because it holds in check the invading malignant growth.

It is highly important to subject nodes and tissues to microscopic examination during operation in order to ascertain if one is working in an invaded area. A detailed consideration of lymphatic metastasis may be found in the section on Carcinoma of the Rectum.

**Symptoms**—To record in sequence the chain of symptoms caused by carcinoma of the large bowel is difficult if not impossible particularly if it is desired to emphasize merely the earlier manifestations of the disease.

The reasons for this are that developmentally anatomically and physiologically the right and left halves of the bowel differ so much that the colon is virtually a dual organ and the symptoms of carcinoma vary according to the situation of the lesion, the pathologic type and the presence or absence of complications such as metastasis, perforation or ulceration. The right half of the colon is the absorptive half and is comparable in function to the small bowel with which it has a common embryonic origin. From the papilla of Vater to the middle of the transverse colon the large intestine develops with the small intestine from the ileum and the function of this whole primordium is digestion and absorption. Beyond the middle of the transverse colon the large bowel is developed from the ileocecal junction and its duty is one of storage. The two halves are not only different anatomically so far as the structure of the wall of the bowel is concerned but they derive their blood supply from different sources, the superior mesenteric artery supplying the digestive or absorptive part of the gastrointestinal tract and the inferior mesenteric artery supplying the distal half.

The onset of symptoms usually signifies absorption rare occasions may occur with explosive suddenness and although there are few characteristic early symptoms a warning ordinarily is given by a change of bowel habit or irregularity of the bowel such as mucous diarrhea, or alternate periods of diarrhea and constipation. Chronic diarrhea in an elderly person frequently proves to be due to a malignant growth and the aplorism of Morison. Increasing constipation of recent origin in an elderly person only overcome by purgatives suggests malignant disease of the colon. Equally true. Approximately 90 per cent of carcinomas of the entire colon present no more definite symp-

penetration perforation or the formation of abscess. On the other hand in the distal segment of the large bowel carcinoma usually originates close to the mucosal border and spreads laterally diminishing the size of the lumen and consequently producing chronic subacute and even acute obstruction (Fig 577 B). One may however occasionally encounter a polypoid lesion.

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The onset of symptoms usually is insidious but on rare occasions may occur with explosive suddenness and although there are few characteristic early symptoms a warning or warning is given by a change of bowel habit or irregularity of the bowel such as mucus or diarrhea, or alternate periods of diarrhea and constipation. Chronic diarrhea in an elderly person frequently proves to be due to a malignant growth and the aphorism of Morrison "Increasing constipation of recent origin in an elderly person only overcome by purgatives suggests malignant disease of the colon" is equally true. Approximately 25 per cent of carcinomas of the cecum present no more definite symp-

times in the early stages of the disease. The obvious corollary to this is that thorough investigation of the gastrointestinal tract should be made if a change in intestinal habit or irregularity persists over a period of weeks.

**Right Half of the Colon**—In this segment of the bowel the large flat ulcerating growths present a wide surface for absorption thus interfering with the function of the mucous membrane and giving rise to profound intoxication and anemia without a tendency to produce obstruction.

In most cases the symptoms of carcinoma in the right side of the colon may be classified under three main groups: (1) so called "dyspepsia" mild in character with few localizing symptoms and usually diagnosed as chronic appendicitis or chronic cholecystitis; (2) profound anemia, loss of weight and loss of strength; and (3) a mass accidentally discovered in the right iliac fossa which on further investigation proves to be a neoplasm.

The first group represents a high percentage of latent unsuspected cases of carcinoma of the right half of the colon which may be interpreted early if the advisability of roentgenologic examination is urged. There may be no more warning other than a change in bowel habit or bowel irregularity or alternating periods of diarrhea and constipation. Pain and local tenderness simulating subacute or chronic appendicitis without a tendency to disappear occasionally are found to be the early signs of cecal carcinoma.

In the second group that characterized by anemia, weakness and loss of weight one element is outstanding—profound anemia with a concomitant decrease in the entire blood picture yet without visible loss of blood. Attention may be called to such anemia by the patient's inability to carry on his work or by unexplained weakness or it may be found on examination without apparent cause. An exact explanation of this type of anemia cannot be given but it is probably due in part to some perverted or inhibited function of the mucous membrane which impairs it to such an extent that absorption of toxins from the broad infected surface of the growth occurs, the work of Whipple, Schmidt, Koons and others has demonstrated this fact.

In the third group the condition is accidentally discovered in the right iliac fossa by the patient or during a routine physical examination.

**Left Half of the Colon**—The syndrome of neoplastic growths of the left half of the colon is evidenced more by acute subacute or chronic symptoms of obstruction than by physiologic disturbances. Borborygmus and visible peristaltic movements associated with increased flatulence are of frequent occurrence. Visualization of peristalsis is possible only if the patient is lean.

**Progressive constipation** occurs in a high proportion of these cases, probably between 25 and 40 per cent and should call attention to the presence of some mechanical stenosis in the majority of cases before roentgenologic evidence is sought. The obstruction may be either acute or chronic. If it is the former it may be due to volvulus, intussusception, plugging of the lumen of the bowel by a foreign body or edema due to an inflammatory process superimposed on the malignant condition. The chronic form of obstruction occurs in a considerable number of cases of carcinoma of the colon owing to direct encroachment on the lumen of the bowel and dependent on the pathologic type and rapidity of the growth. Acute intestinal obstruction secondary to malignant growth is an extremely grave condition and in the writer's experience occurs in approximately 5 per cent of cases of carcinoma of the large bowel. The chances are 6 to 1 according to Burgess that the lesion is to the left side of the colon if it is the etiological factor to be considered.

Blood in the stool is a symptom which is usually emphasized in any consideration of carcinoma of the large bowel. It is the writer's conviction that blood must be bright red or that continual tests for positive occult blood must be made before significance can be attached to its presence. Blood in the stool may come from any portion of the alimentary tract. If tests for occult blood give positive results the lesion may be anywhere between the buccal cavity and the rectum and in the writer's experience this has been of more significance in the diagnosis of unusual tumors of the small bowel than of lesions of the colon and rectum. Tenesmus as a symptom of carcinoma of the colon is



not significant except when the growth is close to the rectum

The tendency to perforation and formation of abscess in this segment is common. Ulceration aggravated by constant irritation of the solid column of feces progresses to subacute perforation in many instances.

It cannot be too strongly emphasized that symptoms such as great loss of weight, cachexia, dehydration and desiccation commonly set down in textbooks as symptoms of carcinoma of the large bowel are in reality symptoms of metastasis and an approaching lethal state and that the respon-



Fig. 578.—Annular carcinoma of the sigmoid.

sibility of waiting for the development of such a chain of evidence to establish a diagnosis of carcinoma falls on the examining physician.

**Diagnosis.**—Roentgenologic examination is the most satisfactory single diagnostic aid for growths beyond view with the proctoscope, namely the middle of the sigmoid flexure. Although certain combinations of well known symptoms and signs are unquestionably suggestive diagnostically, careful roentgenologic examination is virtually indispensable for decisive determination of the exact situation of a growth. Roentgenograms reveal a permanent filling defect that

is almost pathognomonic of carcinoma (Fig. 578). The opaque enema is by far the most accurate method of diagnosis and further, more in obstructing growths the oral meal is a positive menace since it may produce acute intestinal obstruction superimposed on a chronic process.

A differential diagnosis must be made in the main from hyperplastic tuberculosis of the colon, diverticulitis, polyposis, syphilis, segmental ulcerative colitis, chronic retrocecal appendicitis (which is associated with intermittent symptoms and a palpable mass) and actinomycosis.

**Treatment.**—Surgical removal of carcinoma of the colon unquestionably precedes all other measures from the standpoint of curability. If a lesion cannot be removed in a radical manner that is by extirpation of the local growth and lymph nodes in the immediate juxtaposition, a side tracking operation or some palliative measure often may be employed.

**Operability and Prognosis.**—Operability of carcinoma of the colon depends on distant metastasis, lymphatic involvement, local attachment of the growth and the resistance of the patient. Obviously, extensive operation for carcinoma of the colon should not be undertaken without a thorough preliminary exploration of the liver and pelvis for metastasis. All nodes should be subjected to careful microscopic study. Attachment to the abdominal wall involves a more serious risk and may be due to perforation of the growth or to inflammatory reaction. It is not incompatible however with satisfactory end results to excise a large portion of the anterior or lateral parietes provided there is not a better reason for excluding a radical operation. Broders' index of grading malignancy (see section on Carcinoma of the Rectum) permits one to recognize at the operating table types which are favorable and types which are unfavorable from the standpoint of prognosis. In a study of 753 cases of cancer of the colon Rankin and Olson found that the percentage of five year cures in growths which projected into the lumen was 42 per cent against 41 per cent for growths that extended toward the serosa.

It should be borne in mind that factors other than the technical performance of the operation such as the patients' general con-

dition ofesity and age are important. The general condition of the patient as evidenced by the degree of anemia and dehydration attendant on the concomitant intoxication from obstruction is significant in influencing operability. Anemia commonly associated with the right segment of the colon is not a contraindication to exploration and resection even though the concentration of hemoglobin is as low as 25 to 30 per cent. On the other hand anemia in a case of carcinoma of the left half of the colon is a contraindication against resection. Given the same pathologic process in two patients of the same age and otherwise apparently equal chances, it is found that the obese patient is a greater operative risk with a poorer outlook from the standpoint of ultimate cure. Age influences greatly the prognosis of carcinoma of the colon. The clinical observation has been proved many times that the younger the patient the more rapid the growth and the more widespread the dissemination. When the lymphatic structures of advanced age have undergone atrophic changes and are no longer active carcinoma is held in check and remains local for a much longer period than when the subject is young and possesses vigor and vitality.

Additional factors which influence immediate prognosis in operating on the colon are: (1) adequate preoperative rehabilitation combined with the necessary decompression measures; (2) selection of the optimal time for operation and selection of the operation for the patient rather than an attempt to standardize procedures and to fit cases of carcinoma to one or two maneuvers; (3) employment in a large number of cases of operations in multiple stages; (4) selection of an anesthetic suitable to the individual case; and (5) rigid adherence to a standardized postoperative regimen.

**Choice of Operation.**—Several factors influence the choice of operation in the two parts of the colon. The matter of graded operations on each side however is of greatest importance. It is now generally agreed that graded procedures in surgery of the colon and rectum enhance markedly the final satisfactory outcome. That this must be accomplished frequently with disregard of the economic situation of the patient and of the

protests of both patient and physician against prolonging the convalescence is unquestionable and yet ultimately to accomplish either cure or prolonged palliation must be the aim of all surgical procedures.

In operating on the right half of the colon it is the writers' feeling that ileocolostomy between the terminal ileum and the transverse colon followed by resection of the right segment at the same or a subsequent stage is the procedure of choice. Whether the resection is to be done at once or subsequently is a decision which must be made at the operating table in each case on its own merits. The employment of end to side anastomosis rather than lateral anastomosis is preferred in this particular instance because of the desirable feature which the end to side method possesses over the lateral in side tracking the fecal current and allowing as much reduction of local inflammatory reaction around the growth as is possible. Moreover the end to side union more nearly approximates the natural anatomic relationship of ileum and cecum.

In the left half of the colon where obstruction is the most alarming symptom the problem is different. If the obstruction is acute and the bowel dilated, edematous and filled drainage by cecostomy or colostomy proximal to the growth is urgently indicated. If on the other hand as happens in the majority of cases the obstruction is mild and has been relieved by preoperative measures resection frequently may be accomplished in one stage but without anastomosis. The writers do not believe that primary anastomosis should be carried out on the left half of the colon except in extremely rare instances and when it is a cecostomy or colostomy proximal to it is always indicated. Simultaneous decompression with the Miller Abbott tube is commendable as an additional safeguard but should not be employed as a substitute for cecostomy or colostomy which are more uniformly dependable.

It is apparent that the advent of sulfasuxidine has led some to abandon entirely the principles of multiple stage procedures notwithstanding the fact that the uncertainty in regard to the blood supply of the divided ends of the colon continues to make primary anastomosis a hazardous undertaking. It is our firm conviction however that

the economic factor in dealing with carcinoma is one which may be disregarded advantageously when the time comes to select operative procedures for by spending more time preoperatively and in carrying out multiple operations lower mortality and a higher percentage of satisfactory end results may be the reward.

In the average case in a mobile segment of bowel the procedures available are (1) obstructive resection (Rankin) (2) a cecostomy followed two or three weeks later by resection and anastomosis (3) an exteriorization operation such as that described by Paul Block or Mikulicz. Frequently in this country all such procedures are erroneously referred to as the Mikulicz operation.

Obstructive resection combines the desirable features of the old type of exteriorization operation in one stage making it a radical operation removing the growth and gland-bearing tissue together and leaving the bowel obstructed for a period of from forty-eight to seventy-two hours. In the event of obstruction unrelieved by medical measures it will of course be necessary to resort to cecostomy before such a procedure is employed. The usual exteriorization operation is merely a local excision and is accompanied by a high mortality when a large series of cases is considered. At the same time it resulted in recurrence of the growth in the abdominal wall in 12 per cent of a large series of cases and a high percentage of recurrences of intra-abdominal malignant lesions because of failure to accomplish widespread block dissection of the gland-bearing tissues in juxtaposition to growth.

**Operative Procedures**—It is always advisable to hospitalize the patient for a period of time sufficient to enable decompression of the obstructed colon and restoration of the hypertrophied and often edematous bowel to a healthier state to combat dehydration and the effects of malnutrition and to permit an investigation of the function of the other organs of the body. The importance of such a practice as a routine cannot be overestimated. A satisfactory regime during this preoperative interval briefly is as follows: (1) repeated colonic irrigations with normal saline solution (2) high caloric low residue diet consisting chiefly of

carbohydrates (3) forced fluids orally subcutaneously or intravenously, (4) transfusions when indicated (5) special measures directed toward overcoming concurrent disease in the other organs (6) sulfadiazine parenterally if the sulfonamides are employed because the effectiveness of these drugs depends in great measure upon the systemic presence of the drug consequently they are definitely more dependable than succinyl sulfathiazole (sulfasuxidine).

**Measures of Decompression**—The dangers of increased intracolonic pressure may be minimized by the establishment of a safety valve in the intestine such as that resulting from appendicostomy, cecostomy, ileostomy or colostomy (Fig 579). This may be accomplished several days or weeks prior to resection depending on the degree of obstruction present or it may be done at the time of resection as an additional precaution. Cecostomy is the procedure more generally favored.

**1 Appendicostomy**—The appendix is delivered through a McBurney incision as for appendectomy and the wound closed in layers about the protruding organ. In case of urgent necessity the appendix may be divided at once and a catheter introduced otherwise it is best to wait for forty-eight hours.

**2 Cecostomy**—Cecostomy may be accomplished satisfactorily by one of several methods (Gibson, Hendon, Witzel or Hader) with small likelihood of the subsequent formation of a fistula. A right rectus or a McBurney incision may be employed. A No. 30 French soft rubber catheter is placed in the cecum and held by a purse string suture which also inverts the incised wall of the cecum.

If the Gibson technique is employed two other layers of sutures extend from the tube up and down the bowel so as to form a broad surface which will adhere to the peritoneum (Fig 579). The Witzel technique as applied to the cecum is identical with the widely employed ileostomy of the same name which is described elsewhere. In performing cecostomy it is the writer's custom to use a large mushroom catheter after having cut off the top of the mushroom portion a procedure suggested by Hendon. The cuff-like structure which is left at the end of the

catheter prevents the tube from coming out before the desired time

4 *Ileostomy*—The choice of methods depends on whether the ileostomy is to be permanent or temporary. As a preliminary procedure to total resection of the colon for multiple malignant growths the writers prefer the simple technic shown in figure 579. The John Young Brown and Harvey Stone methods are more complicated and are per-

rectum is the most usual procedure. However, colostomy may be advantageously performed in the transverse colon as a procedure substituted for cecostomy and appendicostomy for an obstructive lesion of the left half of the colon. Fecal control following colostomy has been the object of ingenious procedures directed toward the manufacture of a sphincter muscle. This however is not necessary for if the bowels

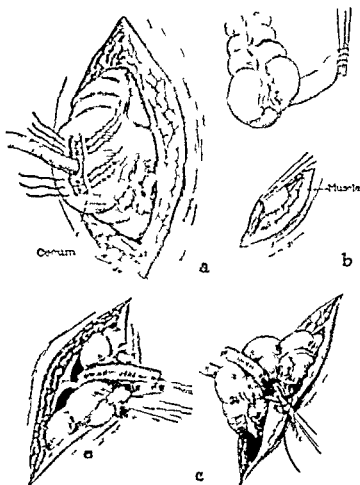


Fig. 579.—Measures of decompression. a. Gibson colostomy: permanent ileostomy; the cecal end of the ileum is inserted, the terminal ileum is brought out as a McBurney in a left inguinal colostomy, the peritoneum and skin are approximated and sutured separately beneath the sigmoid; no sutures are placed in the bowel.

formed with the idea of subsequent reestablishment of the continuity of the intestinal current. The Witzel type of enterostomy is usually satisfactory as a temporary measure particularly when established in the terminal ileum proximal to the suture line in resection of the right half of the colon.

4 *Colostomy*—Establishment of colostomy in the sigmoid flexure through an inguinal incision preliminary to resection of

are trained to be constipated, the results of colostomy regardless of the type are usually satisfactory. The simplicity of the left inguinal colostomy commends it. Moreover, herniation or weakness of the abdominal wall about the stoma is far less frequent than when colostomy is established in the right rectus muscle.

In performing left inguinal colostomy an incision comparable to the McBurney split

muscle incision is made in the left lower quadrant of the abdomen. The sigmoid is brought out of the incision until its most fixed position close to its juncture with the descending colon is reached. The sigmoid distal to this point of mesenteric attachment is at the same time fed back into the abdomen. In this manner it is possible to insure against herniation of the mucous membrane of the proximal loop.

With the aid of a pointed forceps a hole is made in the mesosigmoid and a rubber tube is pulled through and retained for traction on the bowel during the remainder of the procedure at completion of which a glass tube is substituted for the tubing. The peritoneum at the middle of the incision is pulled under the bowel through the rent in the mesosigmoid and sutured to the peritoneum of the opposite side (Fig. 579). In the case of a permanent colostomy the skin in a similar manner is pulled under the lifted loop of bowel and sutured to skin with silk worm gut. The abdominal wound is closed loosely around the bowel. Stitches are not placed in the bowel. The bowel is opened with a cautery usually forty-eight to seventy-two hours later.

**Measures of Extirpation of the Colon.**  
**A Resection of the Right Side of the Colon.**—The operation if in one stage or two stages consists of two distinct procedures: (1) ileocolostomy by which continuity of the lumen of the bowel is restored and (2) mobilization and resection of the right side of the colon and the anastomosis can be made end to end, end to side or laterally; it can be accomplished by the open suture method or with a Murphy button by a closed method such as the Parker-Kerr basting stitch or by means of the Rankin clamp. The open suture method of anastomosis has been adequately described elsewhere in relation to resection of other portions of the gastrointestinal tract. The relative safety and simplicity of the clamp method which the writers have employed with a high degree of satisfaction for over ten years commend it.

**1 Ileocolostomy (Rankin clamp method).**—The terminal portion of the ileum about 10 cm. from the ileocecal valve is divided between clamps, one of which is the special three-bladed clamp (Fig. 580 A). The end

toward the cecum is inverted and dropped back to be removed with the colon. A point selected on the anterior surface of the transverse colon is fixed by the other blade of the clamp containing the ileum and an elliptical piece of the colon is removed with a cautery to make an opening in its lumen. Sutures are then applied anteriorly and posteriorly separately. As the clamp is opened and withdrawn the two free ends of the anterior sutures are drawn taut thus inverting the two ends of the bowel. A layer of sutures is then inserted around the entire end to side anastomosis.

**2 Mobilization and Resection of the Right Side of the Colon.**—This constitutes the second stage of the clamp method and is accomplished either immediately on completion of the ileocolostomy or at a second stage (Fig. 580 A). The peritoneal attachments to the lateral abdominal wall are divided and the whole colon is rotated mesally, the fat and lymphatics being wiped inward with gauze. The spermatic vessels come into view at the lower angle of the wound and as dissection is carried upward the ureter is observed. In mobilization of the hepatic flexure of the colon the second portion of the duodenum is revealed and must be studiously avoided since injury to this structure is corrected with difficulty and carries with it a high mortality. The mesenteric blood vessels are clamped and ligated as they present themselves. A satisfactory point is chosen in the transverse colon proximal to the anastomosis between the ileum and colon and the bowel is divided between clamps with a cautery. The distal end of the divided transverse colon is inverted and brought into the upper end of the abdominal wound as it is closed. The raw surfaces should be peritonized.

**B Resections of the Left Side of the Colon.**—The high incidence of peritoneal infection subsequent to opening the colon together with the uncertainty in regard to the blood supply of the divided ends makes primary anastomosis of the colon by either the open or the closed method highly dangerous. However, if such an anastomosis seems advisable it can be accomplished by: (1) open anastomosis, (2) a Murphy button, (3) closed procedures such as the Parker-Kerr basting stitch and (4) the

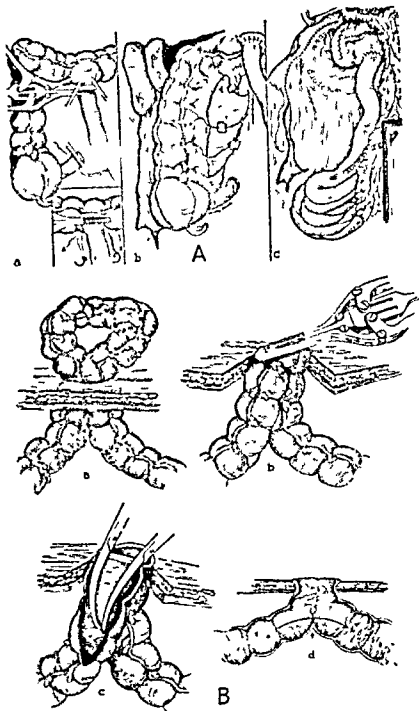


Fig 580.—A Ileocolostomy, Rankin clamp technique and resection of the right half of the colon. *a* The special clamp one blade of which holds the proximal end of divided terminal ileum is being applied to a point selected on the transverse colon for the colonic end of the anastomosis. The elliptical portion of colon that will protrude above the clamp is removed with a cautery. The cecal end of the divided ileum is being inverted. The insert shows the anterior layer of sutures the posterior layer having been applied first (*A*, posterior suture; *B*, anterior suture). *b* Beginning mobilization of the cecum and ascending colon after incision through the parietal attachment of bowel. Primary ligation of the main arteries simplifies the operation. End to side ileocolostomy has been established. *c* Resection of the right half of the colon is completed and the raw surfaces left by the dissection have been closed with a continuous suture. An enterostomy has been established in the ileum just proximal to the anastomosis. *B* Exteriorization procedures which necessitate reestablishment of the bowel continuity and closure of colostomy. *a* The so-called Mikulicz type of exteriorization, *b* obstructive resection employing the Rankin clamp, *c*, application of clamp to the septum separating the approximated loops of bowel, *d*, the septum has been removed and bowel continuity restored.\*

\* Rankin and Graham: *Surgery of the Colon and Rectum*. Charles C. Thomas, Publisher.

muscle incision is made in the left lower quadrant of the abdomen. The sigmoid is brought out of the incision until its most fixed position close to its juncture with the descending colon is reached. The sigmoid distal to this point of mesenteric attachment is at the same time fed back into the abdomen. In this manner it is possible to insure against herniation of the mucous membrane of the proximal loop.

With the aid of a pointed forceps a hole is made in the mesosigmoid and a rubber tube is pulled through and retained for traction on the bowel during the remainder of the procedure at completion of which a glass tube is substituted for the tubing. The peritoneum at the middle of the incision is pulled under the bowel through the rent in the mesosigmoid and sutured to the peritoneum of the opposite side (Fig 579). In the case of a permanent colostomy the skin in a similar manner is pulled under the lifted loop of bowel and sutured to skin with silk worm gut. The abdominal wound is closed loosely around the bowel. Stitches are not placed in the bowel. The bowel is opened with a canter usually forty-eight to seventy-two hours later.

### Measures of Extirpation of the Colon

#### *A Resection of the Right Side of the Colon*

—The operation if in one stage or two stages consists of two distinct procedures: (1) ileocolostomy by which continuity of the lumen of the bowel is restored and (2) mobilization and resection of the right side of the colon and the anastomosis can be made end to end, end to side or laterally; it can be accomplished by the open suture method or with a Murphy button by a closed method such as the Parker-Kerr basting stitch or by means of the Rankin clamp. The open suture method of anastomosis has been adequately described elsewhere in relation to resection of other portions of the gastrointestinal tract. The relative safety and simplicity of the clamp method which the writers have employed with a high degree of satisfaction for over ten years commend it.

#### *1 Ileocolostomy (Rankin clamp method)*

—The terminal portion of the ileum about 10 cm. from the ileocecal valve is divided between clamp, one of which is the special three-bladed clamp (Fig 580 A). The end

toward the cecum is inverted and dropped back to be removed with the colon. A point selected on the anterior surface of the transverse colon is fixed by the other blade of the clamp containing the ileum and an elliptical piece of the colon is removed with a cautery to make an opening in its lumen. Sutures are then applied anteriorly and posteriorly separately. As the clamp is opened and withdrawn the two free ends of the anterior sutures are drawn taut thus inverting the two ends of the bowel. A layer of sutures is then inserted around the entire end to side anastomosis.

*2 Mobilization and Resection of the Right Side of the Colon*—This constitutes the second stage of the clamp method and is accomplished either immediately on completion of the ileocolostomy or at a second stage (Fig 580 A). The peritoneal attachments to the lateral abdominal wall are divided and the whole colon is rotated mesally, the fat and lymphatics being wiped inward with gauze. The spermatic vessels come into view at the lower angle of the wound and as dissection is carried upward the ureter is observed. In mobilization of the hepatic flexure of the colon the second portion of the duodenum is revealed and must be studiously avoided since injury to this structure is corrected with difficulty and carries with it a high mortality. The mesenteric blood vessels are clamped and ligated as they present themselves. A satisfactory point is chosen in the transverse colon proximal to the anastomosis between the ileum and colon and the bowel is divided between clamps with a cautery. The distal end of the divided transverse colon is inverted and brought into the upper end of the abdominal wound as it is closed. The raw surfaces should be peritonized.

*B Resections of the Left Side of the Colon*—The high incidence of peritoneal infection subsequent to opening the colon together with the uncertainty in regard to the blood supply of the divided ends makes primary anastomosis of the colon by either the open or the closed method highly dangerous. However, if such an anastomosis seems advisable it can be accomplished by: (1) open anastomosis, (2) a Murphy button, (3) closed procedures such as the Parker-Kerr basting stitch and (4) the

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writers clamp method. To obviate the dangers incident to increased intracolonic pressure in such procedures either cecostomy or colostomy proximal to the anastomosis should be provided. Procedures which can be used instead of primary anastomosis are (1) the old type exteriorization operation and (2) the obstructive resection of Rankin. The open suture method of anastomosis has been adequately described elsewhere in relation to resection of other portions of the

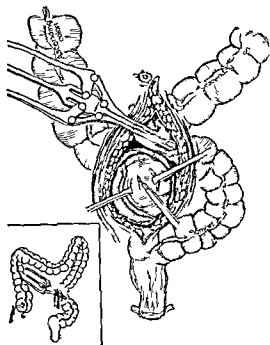


Fig. 531. Obstructive resection of the colon. The special clamp is seen applied to the two ends of bowel and a cecostomy is being performed. The mesenteric blood vessels have been ligated near their points of origin and a wide expanse of mesentery has been sacrificed along the segment of colon harboring the growth. The insert shows the wound closed and the clamp in situ; the handle of which rests upon the abdomen.

gastrointestinal tract. The obstructive resection utilizes all the satisfactory fundamental principles of the exteriorization operation yet avoids its disadvantages. It is applicable to any portion of the colon that is mobile or mobilizable.

**1. Obstructive Resection of the Colon.**—The segment of the bowel harboring the growth is delivered into the wound after the peritoneal attachments to the lateral abdominal wall are divided in order to insure mobility. The vessels are then ligated

close to the root of the mesentery and the intervening expanse of mesentery with its regional lymph nodes is widely excised. The special three-bladed clamp which the writers use for aseptic anastomosis is applied to the two limbs of colon (Fig. 531) care being taken at this stage to insure a good blood supply to the two ends of the bowel. Just above this clamp another is placed and between these the bowel is divided with a cautery. The rent in the mesentery is closed and all raw surfaces are peritonized. The clamp is then brought out of the wound, the edges of which are approximated snugly above the limbs of bowel; no stitches actually being taken in the colon. The bowel is then left totally obstructed for at least forty-eight hours and usually for as long as seventy-two hours. Untoward symptoms will not develop if proper preoperative cleansing measures have been carried out. In those cases of obstruction in which the patient fails to respond to preoperative treatment, cecostomy should be resorted to before the obstructive resection is attempted. The remainder of the operation is accomplished as in the exteriorization procedure that is the spur is cut with an enterotome or with clamps and after at least a month the fistula is closed surgically, provided a spontaneous closure has not already taken place.

**2. Exteriorization Operation.**—The growth-containing segment of bowel is delivered into the abdominal wound as in the obstructive resection but the mesenteric blood vessels and lymphatic structures are left intact. The abdomen is then closed tightly around the extruded mass which is surrounded with petrolatum gauze in an attempt to prevent transplantation of carcinoma cells to the abdominal wall. The second stage, which may be performed any time after forty-eight hours, consists in the removal of the protruding bowel flush with the abdomen. The third stage entails removal of the intervening partition between the two loops of bowel with clamps and finally closure of the colonic stomas.

**Mortality and Recurrence.**—See section on Carcinoma of the Rectum.

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## XXIX ANAL CANAL AND RECTUM

### ANATOMY, CLARIFICATION OF TERMS ETC

Doctors and medical students alike are frequently guilty of considerable laxity in their use of proctologic terminology. Perhaps they feel that careful differentiation of anorectal terms is of academic interest only. In reality they would be amply repaid by a simpler conception of symptomatology of diagnosis and of treatment of anorectal disease if they were willing to learn the funda-

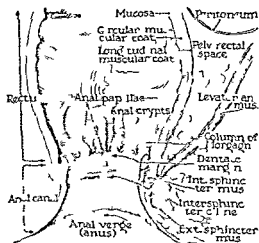


Fig. 54—A schematic representation of the anorectal canal (coronal section)

mental principles of anatomy and of nervous physiology as applied to the anorectum.

Study of the developmental anatomy has shown that the anal canal is derived from the embryonic proctodeum hence anal structures are ectodermal in origin. The rectum is entodermal in origin being derived from the hindgut. The anal plate which early occludes the anorectal outlet disintegrates at about the seventh week of fetal life. Complete or partial failure of these processes accounts for the variety of anomalous defects occasionally seen e.g. an imperforate anal canal.

The anal canal forming the terminal por-

tion of the intestinal tract varies in length from 1.5 to 2.5 or 3 cm. Its superior border is the *dentate margin* the inferior boundary is the *anus* or anal verge the anus being considered a *rima* in the anatomic sense (Batson<sup>1</sup>). The *anal canal* is lined by skin not by mucous membrane—the term *anal mucous membrane* being a misnomer. The dentate margin comprises the anal semilunar valves and the anal papillae together with the anal crypts (Morgagni). There are several terms used synonymously with dentate margin namely pectinate line and anal rectal line and mucocutaneous line or border. The term white line of Hilton refers to the intersphincteric line it is not synonymous with the aforementioned terms and had best be forgotten in order to avoid further confusion (Fig. 58<sup>2</sup>).

**Nervous Physiology.**—The skin lining the anal canal investing the anal papillae and partially lining the anal crypts receives a somatic sensory nerve supply. Accordingly, therefore nearly all lesions involving anal structures are painful notably thrombosis of an external hemorrhoidal vein anal fissure anal abscess cryptitis papillitis etc. The mucous membrane of the rectum is believed to be supplied by visceral sensory nerves. It is not surprising then that rectal lesions except those that involve also the dentate margin are not accompanied by pain early in their course. Likewise internal hemorrhoid can be injected and polyp can be fulgurated without anesthesia. Somatic motor nerves supply the external anal sphincter and the levator ani muscles (striated) whereas the internal sphincter muscle (smooth) and the rest of the smooth muscle of the gut receive a visceral motor nerve supply.

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## CRYPTITIS, PAPILLITIS AND FISSURE IN ANO

**Cryptitis.**—The crypts of Morgagni are of the utmost importance in the etiology of infectious anorectal diseases. Because each of the crypts has a blind pouch at its lower end which easily catches and retains foreign particles of all kinds and because the crypts are subjected to traumatization by hard stools infection is not uncommon. The infection is usually due to ordinary pyogenic organisms although tuberculous and gonorrheal infections are not infrequent. In case of tuberculous infection a fistula usually develops promptly. Gonorrheal infection is accompanied by proctitis. The gonococcus is usually quickly overgrown by other organisms found in the rectum and the proctitis subsides but chronic cryptitis remains.

The usual symptoms of chronic cryptitis are the feeling of vague discomfort and heaviness in the rectum with low grade dull pain radiating into the buttocks and perhaps down the back of the thighs. When a single crypt is involved the discomfort can be definitely located in one limited area. Periods of remission and exacerbation of symptoms are a definite characteristic of this disease. A small amount of mucus either tinged with blood or not may be noticed on the first part of the stool but often this is not present. Digital examination will reveal each involved crypt to be definitely tender on pressure. On examination with a bivalve speculum so that the folds and crypts are spread open their bases are seen to be red and granular. The mucosa lining the crypt bleeds more readily than normally, and a blunt hook will reveal particularly in the lower pocket like portion varying degrees of tenderness. It is from such a diseased crypt that many other anorectal diseases develop. Anal fistulas in particular are almost always the result of cryptitis. After the crypt becomes infected the infection may spread through its wall by direct continuity through the small tubular ducts or by way of the lymphatics and then form a perirectal abscess. When this abscess ruptures or is incised the cycle of fistula formation is completed. If the infection is of low virulence and if when it penetrates the wall of the crypt it extends downward just

beneath the anoderm\* rather than invading the deeper structures a fissure will result. The actual fissure is produced when the anoderm over the infected area becomes friable and breaks down thus leaving a typical shallow ulcer.

The extent of the importance of cryptitis in the formation of the so called idiopathic type of ulcerative colitis has not been definitely determined. The origin of ascending proctitis in cryptitis is relatively frequent. Another condition resulting from cryptitis is narrowing or stricture of the rectum just at the anorectal juncture a condition commonly called *pectinosis*.

The treatment of cryptitis is both surgical and medical. In the writer's experience except in the acute cases or the mildest type of the more chronic cases medical treatment is usually unsatisfactory in so far as permanent results are concerned. The medical treatment which offers the best hope of good results is irrigation of the rectum with warm solutions of boric acid or potassium permanganate or the injection of an ounce of 1 to 400 aqueous solution of metaphen. 0.5 per cent mercurchrome or 10 per cent argyrol. In addition the physician should see the patient frequently dilating the anal canal and the lower portion of the rectum with a bivalve speculum. With the crypts thus spread open their bases should be swabbed with silver nitrate (1 to 10 per cent). The difficulty with all medical treatment lies in the fact that at the lower end of each crypt lies a pocket or pouch which does not drain adequately and hence is difficult to clear of infection. The removal of this pocket and the securing of adequate drainage of the entire crypt will usually result in permanent cure. This operation may be done in the physician's office a local anesthetic being used though for a nervous patient twenty-four or forty-eight hours of hospitalization may be advisable. A number of methods of operation are advised but the most simple and satisfactory method is the following. A hooked probe is inserted into the pocket of the crypt. The flap of the pocket is then raised on the hook and removed in its en-

\* The anoderm the epithelial lining of the anal canal differs from ordinary skin in that the former has neither hair follicles nor sweat glands and its epithelial cells are flatter.

tured with curved scissors. It is important that the cut edges of the pocket be kept from adhering together and this can be accomplished by frequent digital examination and the palpation of each crypt which has been operated upon. The use of some astringent ointment such as nupercaine (1 per cent) and a mild antiseptic such as metaphen is usually all the postoperative care necessary. The patient, however, should be seen frequently until healing is complete.

**Papillitis**—Papillitis is inflammation of the anal papillae which are serrated projections resulting from the breaking down of the anorectal membrane. They are covered with squamous anal epithelium hence they are anal rather than rectal in origin and therefore very sensitive. There is considerable normal variation in the size of these papillae both in different persons and in the different papillae in the same person. When a papilla is quite prominent it will often elongate and hypertrophy as a result of inflammation, the passage of the stool and the action of the sphincter muscle until it may be more than an inch in length. Not infrequently there develops a hard fibrous polypoid nodule on its terminal end. When it becomes inflamed either from an infection in an adjacent crypt or because of traumatization by the stool considerable pain and tenderness which are aggravated by defecation are usually noted. A spasm of the sphincter is also present which makes the symptoms more severe. Occasionally a tear may develop at the point of attachment owing to the pull on the terminal portion by the passage of a stool or the contraction of the sphincter. This may produce all the symptoms of an anal fissure. The treatment of this condition is removal of the offending papillae. This can be accomplished with the use of a local anesthetic; the after treatment being essentially the same as that following excision of a crypt.

**Fissure in Ano.**—While it is true that any crack in the anal skin is a fissure for practical purposes it is well to make a distinction between acute anal or perianal cracks and what should be termed a true fissure in ano. In many persons a crack or abrasion develops following the passage of a hard stool or from some condition which irritates the anal or perianal skin. In thin

skinned persons or those suffering from pruritus ani or other cutaneous conditions about the anus this may occur rather frequently. However if the stool is kept soft and mild applications are used these cracks readily heal. A fissure originates in one of two ways. First, it may originate from an infection of a crypt of Morgagni in which the infection burrows down underneath the anoderm. The tissue over this small sinus breaks down forming an ulcer. Usually a portion of the anoderm over the upper part of the sinus opening into the crypt remains intact. This portion of the tract is in fact a tiny subcutaneous fistula. If then at any time the broken down ulcerated area should heal the little fistula draining into it will cause it to remain infected and to break down again. Hence the futility of local applications in this type of case. There is always a small amount of secretion from a fissure and this causes an inflammatory tab to form at the lower end. It is tiny to begin with but may grow to the size of the end of the little finger—the so-called sentinel pile.

The second type of fissure usually develops from a crack or abrasion in the anal canal caused by trauma. In these cases anal stenosis is almost invariably present. If it does not heal promptly the secretion causes a sentinel pile to develop. If anal stenosis is present recurrence of the fissure is certain unless every stool is kept soft. Since it is practically impossible for a patient to avoid an occasional hard stool recurrence of the fissure is almost inevitable unless the anal stenosis is relieved. Anal stenosis therefore demands surgical treatment. Other infectious conditions in the anal canal due to venereal disease, tuberculosis, etc. may produce ulceration but should not be classed with the true fissures. While a fissure may occur at any point in the anal canal the most common site is in the posterior midline. This is probably due to the fact that the fibers of the sphincter cross here or are inserted into the anococcygeal tendon. A larger and deeper crypt is present in this location than elsewhere and elasticity is less. The direction of the anal canal produces greater traumatization by the stool at this point and the blood supply in this region is more scanty.

In those cases which do not result from infection of an anal crypt or in which no sentinel pile has formed and in which anal stenosis is not present medical measures offer some hope of cure. Recently the injection of certain solutions such as 5 per cent quinine urea hydrochloride or the injection of oily solutions such as 5 per cent phenol in olive oil, benzoic nupercaine in oil or buccaine compound has been advocated for use in the treatment of this condition. From 2 to 5 cc of the solution is injected under the base of the fissure. The prolonged anesthetic action relieves pain and spasm and enables the physician to treat the fissure with various applications. However if a sinus is present at the upper end or if a sentinel pile is present at the lower end or if anal stenosis is present the fissure must be operated upon before a cure can be effected. The writer is convinced that in the majority of cases surgical treatment gives the best assurance of permanent cure. At the same time any other rectal and anal pathologic condition which may be present can be cared for. A number of methods of operation have been devised but only the one which the writer has found to be always successful will be described here.

If any pathologic condition other than the fissure is present spinal anesthesia is generally employed. If only the fissure is present, the intravenous injection of 0.5 per cent pentothal sodium is generally used. After anesthesia the anus is dilated but not divided. A blunt hook is inserted into the crypt above the upper end of the fissure to determine whether or not a sinus extends down to it from the crypt. If so the sinus is excised. Any scar tissue in the base of the fissure is dissected out, and if a sentinel pile is present it is removed. A deep longitudinal incision is now made through the base of the fissure dividing a portion of the sphincter. The incision is carried well outside the anus. The edges of the incision are trimmed away widely enough so that no packing is necessary. Bleeding vessels are secured but no other stitches are used. It is desirable to produce a good sized wound which does not tend to close over too readily. In many cases postoperative difficulties develop because the procedure has not been radical enough. The postoperative care in these cases consists of hot sitz baths twice daily beginning twenty-four hours after operation on the injection of enema mineral oil to insure soft evacuations and local treatment with various applications such as mercurochrome (2 per cent) and thymol iodide dusting powder. Complete healing of the wound is usually obtained in about three weeks.

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## ANAL FISTULA (FISTULA IN ANO)

The Latin word *fistula* means pipe and a piece of pipe has two openings—one at either end. Accordingly therefore the term blind internal fistula or blind external fistula as applied to a tract which ends blindly is a misnomer; the proper term in this instance being sinus. Practically all anal fistulas originate in an anal crypt—hence the term *fistula in ano*.

There seems to exist considerable misunderstanding with regard to anal fistulas and to abscesses which occur in the tissues surrounding the anal canal and rectum. A thorough understanding of the pathogenesis of anal fistulas will simplify the problem and will facilitate treatment. Abscess formation is a definite step in the establishment of fistula in ano; hence the very logical reason for describing abscesses under the heading of fistula in ano.<sup>1</sup>

Stage I. Infectious material invades the anal crypt and the tiny vestigial anal ducts attached thereto.

Stage II. The infection is carried into the surrounding tissues by way of the lymphatics.

Stage III. The infected tissue (usually loose fatty areolar tissue) breaks down into an abscess; the signs and symptoms of which are familiar to every physician—redness, local heat, swelling, tenderness and pain. It is usually at this stage that the patient first seeks medical aid.

Stage IV. The abscess ruptures spontaneously or is incised. Not until drainage has been established can the term *fistula* be properly applied. One opening of the fistula, namely the infected crypt, is provided in stage I. The other opening occurs in stage IV.

Bue has logically termed the infected crypt the primary opening of the fistula. The other opening (single or multiple) is therefore called "secondary" whether it oc-

curs in the rectal wall above the dentate margin or in the skin about the anus or over the buttock.<sup>2</sup>

Now that the role played by an abscess (stage III) in the formation of an anal fistula has been discussed, the various locations involved by abscess formation may be considered. There are no true spaces about the anal canal and rectum; hence one speaks of "surgical spaces" as spaces which can be created by dissection or by dissolution of tissue during the infectious process resulting in an abscess. There are five such spaces: the two ischioanal spaces or fossae beneath the levator ani muscles (Fig 583, a, *I.A.*), the two pelvirectal spaces (Fig 583, a, *P.R.*)

under pressure, because the boundaries of this cavity are fairly rigid. He calls attention further to the fact that the roof of the pelvirectal space is peritoneum, which is capable of being floated upward.<sup>3</sup> Accordingly, therefore, when an ischioanal abscess is incised and a great deal more than 2 or 3 ounces of pus is obtained, one can be reasonably certain that the infectious process has involved a "deep" space (above the levators) as well as a superficial one. Communications between the superficial and the deep spaces occur usually near the anal attachments of the levator muscles.

In figure 583, a the tract labeled *I* leads to an abscess (*Ab*) in the ischioanal fossa

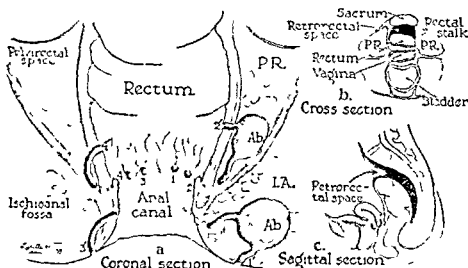


Fig 583—A diagrammatic representation of anal fistulae and of surgical spaces (see text). *P.R.* indicates pelvirectal space; *I.A.*, ischioanal space or fossa; *Ab*, abscess; *I*, *2*, *3*, *4*, fistulous tracts; *I'*, *2'*, *3'*, *4'*, secondary openings.

and the retrorectal space above the levators (Fig 583, b and c). When one or both ischioanal fossae are involved the signs and symptoms are obvious to both the patient and the physician, as previously described, because of the superficial location of the abscess inferior to the pelvic diaphragm. However, involvement of any of the three deep spaces above the pelvic diaphragm is accompanied only by vague symptoms—a feeling of weight or heaviness in the pelvis and possibly chills and fever. The diagnosis depends upon careful digital palpation, which will disclose a "doughy" swelling encroaching on the rectal lumen. Batson has pointed out that the ischioanal fossa can hold no more than 2 or 3 ounces of fluid even

Drainage is established by the secondary opening *I'*. Tract *2* originates at the usual level in an infected crypt but leads to an abscess (*Ab*) above the levator in the pelvirectal space on that side. The abscess has ruptured into the rectum at *2'*, which is the secondary opening of the fistula. Tracts *3* and *4* represent diagrammatically the appearance after contraction of the abscess cavities. Hence the primary openings lie in the anal crypts at the level of the dentate margin. Openings at any other place, either on the skin surface or in the rectal wall, are secondary—and the term fistula-in-ano, still holds because the primary source of the fistula in either case is a crypt, which is an anal structure.

An acute abscess requires drainage. The choice of a point for incision is important. If fluctuation is present an incision should be made at that point but the opening should be made as near the anus as possible in order that the resulting fistulous tract may be as short as possible. In the case of a deep abscess with or without involvement of the ischioanal fossa drainage should be established through the ischioanal fossa on the involved side rather than through the rectal wall. In the case of a retrorectal abscess drainage can be established through the anococcygeal raphe or to either side of it and as near the anus as possible. The author then usually waits for ten or fourteen days before performing fistulectomy.

The treatment of anal fistula is the same regardless of etiology, namely complete exposure of the tract from primary to secondary openings with excision of the overhanging edges so as to create a flat wound. This can usually be done in one sitting and all the existing tracts can be laid open at one time provided of course careful attention is given to after care. An essential feature in fistulectomy is adequate exposure; this is best obtained with either low spinal or sacral block anesthesia. The other types of anesthesia do not permit satisfactory anal relaxation.

There is one notable exception to the opening statement in the foregoing paragraph and that pertains to a fistula which is found in a patient suffering from thrombo-ulcerative colitis (chronic ulcerative colitis). It is not wise to undertake anorectal surgical treatment in these cases because the wound will not heal. It is permissible to drain an abscess but to do a fistulectomy, a hemorrhoidectomy or a fissure operation for a patient suffering from chronic ulcerative colitis is definitely contraindicated.

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## ANORECTAL VENEREAL DISEASE

**Syphilis**—In dispensary practice one occasionally sees primary syphilitic lesions (i. e. chancre) involving the skin of the anal canal. Condylomata lata are the usual secondary lesions found affecting the anal and the perianal skin. Syphilis of the rectum is rare. Treatment has been well organized by the modern syphilologist.

**Gonorrhea**—Anal gonorrhea involves chiefly the anal crypts and anal glands. Rectal gonorrhea affects usually only the lower third of the rectum; the process ranging from mild proctitis to partial or complete destruction of the mucous membrane. Sulfonamides constitute the established treatment although penicillin bids fair to become the agent of choice.

**Chancroid (Soft Chancre)**—These lesions are occasionally seen involving anal or perianal skin as a result of auto-inoculation from a genital lesion although primary implantation in this region is possible. The pain is usually severe. Sulfonamides are practically specific.

**Veneral Lymphogranuloma**—(See sections on Benign Rectal Stricture and Venereal Lymphogranuloma.)

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## BENIGN RECTAL STRICTURE

Benign strictures of the rectum may be either congenital or acquired; the latter in turn may be either extrinsic or intrinsic in origin. Any extrarectal process whether neoplastic or inflammatory can encroach on the rectum with resultant narrowing of its lumen. In these instances however the rectal mucosa is usually intact, being involved only secondarily when there is malignant invasion of the rectal wall. Benign strictures which are intrinsic in origin may be the result of inflammatory disease of trauma or of surgical procedures or of radiation therapy.

In the light of recently acquired knowledge the most common cause of inflammatory rectal stricture is the virus of venereal lymphogranuloma (lymphogranuloma venereum). As the name implies this entity is venereal in origin—the sixth venereal disease according to Stannus.<sup>1</sup> Since the lymphatic drainage of the external genitalia is



inginal in either sex a primary lesion of the external genitals in the male or the female is followed shortly by bubo formation. In the female however the primary lesion is likely to be established in the vagina or on the cervix. As a result the virus can invade the perirectal and rectal lymphatics either by way of the plexus of the rectovaginal septum or through the uterosacral ligaments (rectal stalks). In the male it is possible that the infection may travel along the urethra into the lymphatics of the prostate and thence to the rectal absorbents by way of the rectal stalks. In either sex infection may spread upward from an anal lesion through lymphatic vessels which connect the anal absorbent plexus with that of the rectum. Sodomy might result in direct implantation of the virus in the rectal mucosa. Lymphatic stasis in the presence of infection favors the growth of fibroblasts.\* The fibrous tissue thus formed undergoes contraction. The resultant inflammatory stricture occurs usually in the lower half of the rectum. The Frei test is an established diagnostic procedure. Collier F. Martin<sup>3</sup> has shown that there is no specific treatment thus far for this distressing condition. Surgical procedures are often necessary but the results are disappointing. In far advanced cases the best plan appears to be to establish a permanent colostomy and then to remove the rectum either by posterior resection or by a combined abdominoperineal operation.

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- 2 Drinker C. K. and Field M. F. *Lymphatics, Lymph and Tissue Fluid*. Baltimore: William & Wilkins Co., 1933, pp. 181-187.
- 3 Martin Collier F. Personal communication to the author.

### ANORECTAL TUBERCULOSIS

Space does not permit a detailed account of the role of tuberculosis in anal fistula. Suffice it to state here that the incidence of tuberculous anal fistula is probably below 3 per cent and that modern regional anesthesia permits one to treat a tuberculous anal fistula exactly as outlined in the section on fistula in ano.

Anorectal tuberculosis is not common; it is practically always secondary. Tuttle<sup>1</sup> states: "All tubercular processes of the superficial teguments arrive sooner or later at an ulcerative stage." Accordingly, therefore perianal or anal tuberculosis may be either simple ulcerative or lupoid. Both Tuttle<sup>2</sup> and Buie<sup>3</sup> call attention to the minimal pain accompanying these lesions. In addition Buie refers to lupoid tuberculosis of the anal canal as "proliferative," comparing it with hyperplastic colonic tuberculosis and presents the record to date of a patient whom he has observed since 1921. This story is well worth reading.<sup>4</sup> Rectal tuberculosis is either ulcerative or hyperplastic. Grossly, the specimen of hyperplastic disease resembles closely that of inflammatory rectal stricture due to the virus of venereal lymphogranuloma.

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- 4 Buie<sup>3</sup> p. 260.

### PROLAPSE

Tuttle<sup>1</sup> points out that the terms prolapsus and procidentia—meaning a falling down—are synonymous. Buie's modification of the Tuttle classification is both simple and logical. He divides the types of prolapse into those which are visible and those which are concealed. The visible prolapse may be partial (consisting only of rectal mucosa) or complete (involving all the layers of the rectal wall). In the first degree of complete rectal prolapse the wall of the anal canal is everted too so that there is no groove or sulcus surrounding the protruding mass of tissue. In complete prolapse of the second degree the anal structures retain their normal positions; accordingly there exists a sulcus entirely surrounding the prolapsed gut. Concealed rectal prolapse (Tuttle's third degree of complete prolapse) is an intussusception of the upper portion of the rectum and rectosigmoid into the lower portion of the rectum.

**Etiology**—The chief underlying factor in the etiology of rectal prolapse is an alteration or defect in the supporting structures of the anorectum. The exciting causes in these cases are mechanical strain, disease and injury.

**Diagnosis**—Partial prolapse must be differentiated from hemorrhoidal prolapse. In many instances they are associated. The concentrically arranged ridges on the surface of a completely prolapsed rectum are characteristic features; there is a striking difference between these rings and the radially arranged grooves or sulci seen in hemorrhoidal prolapse. Whenever there is a history of prolapse and examination fails to disclose the deformity, the patient should be asked to strain on the toilet in order to demonstrate his trouble. The nature of the condition is usually rendered quite obvious. The chief diagnostic problem is that presented by concealed prolapse. Examination of the patient in the usual tip up position fails to disclose the trouble because the intussusception is usually reduced by such a position. It may be necessary to examine the patient while he is standing upright in order to visualize the deformity.

**Treatment**—In infants and young children presenting partial prolapse conservative methods are often successful. The patient should be down to defecate and the buttocks should be firmly strapped together during intervals between defecations. In older patients with partial prolapse it may be possible to accomplish satisfactory results with linear cauterization or with injection treatment (preferably quinine and urea hydrochloride 5 per cent).

The reduction of a chronically recurrent prolapse—either partial or complete—is usually accomplished easily by the patient himself who has long since become adept at manual replacement of his deformity. In these instances the anal musculature lacks its usual tone and offers little or no resistance. Oddly enough this atony facilitates both the prolapse and its reduction. The author once asked his preceptor, Collier F. Martin, for an explanation of the patulous or semipatulous anal canal so frequently seen accompanying tumors and strictures of the rectum and rectal prolapse. Martin said he had no scientific explanation for this phe-

nomenon but remarked that a tumor or a stricture or a prolapse is akin to putting a finger on a fiddle string—it somehow alters the tone! Buie has frequently called attention to the existence of a patulous anal canal (which can be contracted at will) in some elderly patients in whom no etiologic factor can be found either locally or in the central nervous system. The author has seen three patients with complete prolapse who could reduce the prolapsed tissue without local manipulation. They were apparently able to create a negative intra-abdominal pressure; the prolapse was literally sucked in.

In acute prolapse resulting from sudden strain or from crushing injury the engorgement of the tissues may become so great that gangrene follows. Reduction in such instances is a difficult problem. If the rectal wall is so friable that perforation is likely to occur the safest procedure is an amputative operation with every precaution being taken against opening the peritoneal cavity and injuring the small bowel which may be present. If only the mucosa is damaged gently but firm attempts at reduction should be undertaken with the patient in the inverted position. If necessary relaxation of the anal canal can be accomplished by regional anesthesia. After successful replacement of the prolapsed gut it is well to confine the patient to bed until the supports of the anorectum have had opportunity to resume a normal state.

When partial prolapse fails to respond to conservative management an amputative operation such as that described by Buie<sup>2</sup> is indicated. If this procedure is carried out properly and if diligent postoperative care is provided the outcome should be satisfactory.

The treatment of complete prolapse is usually surgical, necessitating obliteration of the cul de sac via an abdominal approach. The Moschcowitz operation<sup>4</sup> or some modification of it is indicated. Such a procedure is much safer than any operation done from below—especially for complete prolapse of the second degree in which the protruding mass is likely to contain peritoneum and small bowel.

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## ANAL PRURITUS AND HEMORRHOIDS

## ANAL PRURITUS

Anal pruritus is a common anorectal complaint. Literally the term means anal itching; however it is used loosely to include a group of symptoms of variable importance such as itching burning smarting pricking superficial pain moisture slight bleeding at the time of evacuation and vermiculation. The symptoms are variable and intermittent and are usually worse at night or whenever the patient is laboring under nervous tension. The surface of the perineum scrotum labia and gluteal regions may become involved. The dentate margin limits the disease proximally. Anal pruritus is more common among men than women; it usually occurs among young or middle-aged persons and affects especially so-called tense or nervous persons.

In typical cases the involved skin appears grayish pink, redundant and moist and may or may not show excoriations and abrasions; the perianal hair is diminished in amount or absent. Occasionally the altered skin may appear diffusely reddened, dry, glossy and on palpation warmer than the surrounding skin. The last named condition apparently is a less commonly observed phase of the disease.

Acanthosis nigricans, dermatitis medicamentosa, eczema, leukoplakia, lichen planus and psoriasis are some of the diseases to be considered in the differential diagnosis.

A thorough anorectal examination and sympathetic evaluation of the symptoms are required in each case in order to disclose all clues to the existing factors. Unwarranted fear of carcinoma as a result of the irritation will often cause patients to seek relief.

To facilitate consideration of the treatment of anal pruritus the disease is classified as primary or secondary. Secondary

anal pruritus is the result of another anorectal pathologic process which has produced maceration or irritation. Such a pathologic process usually is obvious if a thorough anorectal examination is accomplished and the removal or correction of the abnormality usually will give satisfactory and prompt relief of the pruritus.

Primary anal pruritus usually is considered as a specific disease but its etiology is extremely obscure and the disease probably is the result of a number of unrelated factors. Local causes such as hemorrhoids, cryptitis, proctitis, enlarged papillae and fungal or streptococcal infection occasionally cause this type of pruritus and efforts to eradicate them may produce temporary relief which is optimistically mistaken for a cure.

**Treatment.**—Any abnormality of physiologic function should be corrected if possible. It is frequently necessary to treat local dermatitis caused by previous therapeutic efforts before attempting curative measures. Washing the involved region with mild soap and cold water and the bare hand usually will help and this measure may be followed by the application of a small amount of ointment which contains tar, menthol, camphor or phenol or a pledget of cotton saturated with undiluted witch hazel may be applied. A cold pack of gauze saturated with witch hazel or a 0.5 per cent aqueous solution of aluminum subacetate may be applied in the more severe cases. Calamine lotion also will aid in some cases as will 5 per cent ichthol or 3 per cent ammoniated mercury ointment in a zinc oxide ointment base. It is advisable to prescribe several types of applications and advise alternating their use because although temporarily efficacious any one agent tends to become ineffective if used constantly.

**Technic of Injection of Alcohol.**—Subcutaneous injection of 20 to 40 cc of a 40 per cent solution of ethyl alcohol will produce a satisfactory result in about 87 per cent of the cases in which it is properly employed.<sup>1</sup> Sacral or low spinal anesthesia is desirable; a 21 gauge needle 80 mm long and a 10 cc Lundy syringe are used to inject the solution. The needle is introduced in the midline 2 to 4 cm posterior to the anus and guided subcutaneously along the right side

of the anus to the anterior edge of the field to be injected. The solution of alcohol is then injected as the needle is withdrawn special care is exercised to introduce the solution proximally as far as the dentate margin and under all of the radial folds of the perianal skin. The process is then repeated on the left side of the anus and if necessary the needle may be introduced anteriorly in order to complete the injection. The injection must be confined to the region covered by the freely movable perianal skin. The injection is painless. Cold packs should be applied for from four to eight hours daily until the slough which frequently occurs is localized or removed after this hot wet packs assist materially. Close observation and intelligent care of the wounds are imperative as such wounds are always infected. If sloughing occurs the patient may have an elevated temperature and may complain of headache, anorexia and generalized aching for several days.

Tattooing with mercury sulfide has been advised and seems to produce encouraging results.

### HEMORRHOIDS

**Thrombosed External Hemorrhoids**—Firm tender painful bluish localized swellings which suddenly appear at the anal margin frequently after abnormal function of the bowel or strenuous work usually are thrombosed external hemorrhoids. They occur as subcutaneous extravasations of blood or thrombi occurring within dilated varices. These lesions may be multiple and their occurrence is not irrefutable proof of the presence of internal and external hemorrhoids. Unless the thrombus is recognized and surgical measures are instituted promptly such treatment is of doubtful value because it will not abbreviate the period of discomfort nor will it prevent recurrence.

If not treated promptly these lesions cause pain for from three to seven days after which they gradually subside during the ensuing three to five weeks and the discomfort diminishes irregularly. A small residual tag of skin may be noted.

For the purpose of treating these lesions they may be divided arbitrarily into three types.

*Type 1*—If the thrombus is attached to the overlying skin as indicated by the presence of localized discoloration at the apex of the swelling a painless incision may be made in the adherent region with a sharp scalpel and the thrombus expressed. The resulting cavity may fill with another blood clot but this will be less painful than the original thrombus. Local cleanliness obtained with soap and water will prevent untoward infection.

*Type 2*—When the thrombus is covered by freely movable skin it may be removed by encircling the involved region by an injection of 1 per cent solution of procaine hydrochloride and the clot evacuated or removed through a radially situated elliptical incision. One or more sutures may be required for hemostasis.

*Type 3*—Internal and external hemorrhoids may become hosts to innumerable tiny thrombi and edema subsequent to unusual straining or strenuous activity. The resultant swelling may be sufficiently severe to cause protrusion of mucous membrane and sloughing of the involved skin and mucosa may occur because of constriction of the anal sphincter injury and infection. When the protruding tissue is first encountered one is tempted to replace it if this is accomplished gently the effort is not amiss. However such an effort more frequently will cause increased pain and swelling. The application of hot wet packs for from four to eight hours daily the prevention of straining and the employment of sedatives will help to provide comfort and the reasonably prompt absorption of the thrombi and edema. After the swelling has nearly subsided hemorrhoidectomy may be performed without added risk.

**Marginal Varicosities**—Occasionally a patient will complain of protruding hemorrhoids which require digital replacement but examination will fail to disclose hemorrhoids of sufficient size to cause such symptoms. If the patient assumes a sitting or squatting position and is asked to strain it will be discovered that the protrusion is a swelling of the perianal region caused by subcutaneous varices or external hemorrhoids and that instead of replacing a protruding mass the patient evacuates the blood from the varices by digital pressure.

These masses frequently are called marginal varicosities. Treatment consists of surgical excision.

### Internal and External Hemorrhoids —

Internal and external hemorrhoids are soft tumors occurring at the anus as a result of the presence of superficial varices. They are irregular in size, shape and distribution. Hemorrhoids covered with mucous membrane are called internal hemorrhoids and those covered by skin are called external hemorrhoids.

Although a lengthy list of etiologic and irritating factors might be provided, it is difficult or impossible to ascertain the exact cause in any given case. Frequently an irritating factor is so apparent that it assumes a dominant position in attempts to determine the causative factors. Present knowledge of the etiology of hemorrhoids is of such slight practical value that our preventive efforts are only palliative.

The symptoms caused by hemorrhoids are numerous; they vary in intensity and occur in all possible combinations. To mention a few symptoms may be of aid: bleeding, pain, protrusion with eversion or physical strain in which the protrusion may reduce itself spontaneously or require digital replacement, secondary anemia with its associated symptoms and alteration of intestinal function attributable to discomfort or irritation, etc. Hemorrhoids are blamed for many distant discomforts, but often they are unrelated or coincidental.

The diagnosis of hemorrhoids cannot be determined by either the history or digital examination alone. A carefully obtained history, a thoughtful evaluation of symptoms and a thorough proctosigmoidoscopic examination are necessary. Nearly all lesions which occur in the anorectal region cause symptoms which are so similar that only with constant intelligent curiosity and a knowledge of anorectal pathology can embarrassing errors be avoided.

**Treatment**—The treatment of hemorrhoids can be divided into three types, namely: (1) palliative, (2) non surgical and (3) surgical. Palliative treatment consists of ingeniously providing sufficient comfort to permit postponement of the application of curative measures. Palliative measures may include avoiding heavy labor, applica-

tion of hot wet packs after defecation and administration of medicinal agents such as mineral oil in order to insure a soft stool and the control of diarrhea or other abnormal function of the bowel.

The *non surgical* type of treatment includes all methods which do not require intentional removal of hemorrhoidal tissue. The injection of chemical solutions into the hemorrhoid in order to produce a sterile inflammatory reaction and the application of electric energy in one of its various forms in order to produce inflammation or actual destruction of tissue are the non surgical methods most frequently employed.

Treatment by injection is used more commonly than electrolysis or electrocoagulation. Numerous solutions have been suggested, but 5 per cent aqueous solution of quinine and urea hydrochloride and phenol in vegetable oil are the solutions most commonly used at present. The 5 per cent aqueous solution of quinine and urea hydrochloride prepared for injection into internal hemorrhoids may be obtained from most pharmaceutical houses. This solution insures a greater margin of safety than most of the other solutions. Injections may be repeated more promptly if necessary, a satisfactory inflammatory reaction is obtained and the solution does not produce permanent palpable scarred nodules.

Small or moderately large internal hemorrhoids uncomplicated by thrombi, edema, protrusion or infection may be treated by this method. A 5 cc glass syringe to which a small-caliber needle 10 cm long is attached can be used for the injection of quinine and urea hydrochloride solution and a tuberculin syringe to which a tonsil needle is attached may be used for the injection of phenol and vegetable oil solution. The hemorrhoid is exposed by means of a Hirschman anoscope; the patient is placed in a semi-inverted knee chest or left Sims position. A point 0.5 to 1 cm above the dentate margin is selected for insertion of the needle and the surface of the hemorrhoid is cleansed with a mild antiseptic solution. The needle is inserted for a distance of 0.3 to 0.5 cm and should be freely movable. The amount of solution injected varies with each hemorrhoid. After the injection of quinine and urea hydrochloride solution is com-

pleted the hemorrhoid should appear distended but not blanched. If phenol and vegetable oil solution is injected 0.12 to 0.6 cc (2 to 10 minims) is sufficient. It is advisable to inject too little solution rather than too much. Twisting the needle before withdrawing it will prevent leakage or loss of solution. One or more hemorrhoids may be injected at one time depending on their size and location and on the patient's reaction.

The injection may cause pain. This usually occurs promptly and persists for several hours but may respond to rest and the administration of acetylsalicylic acid or codeine sulfate. The injected tissue should be observed at least every other day until the inflammatory process has subsided and the physician should require prompt notification if bleeding or protrusion occurs. The injection may be repeated as soon as the acute phase of the inflammatory process has subsided. Sloughing or other complications occurring after non-surgical treatment deserve special care because the wounds are infected. Rest in bed, hot irrigations, hot wet packs, a non-residue diet and sedatives are measures which may be employed in the care of such complications.

*Surgical excision* of internal and external hemorrhoids provides an unusual opportunity for practical application of the knowledge of anorectal anatomy, pathology of hemorrhoids and the principles of plastic surgery. In general it is best to be as radical as necessary but as conservative as possible. No one particular operation pursued step by step will cure all hemorrhoids. A basic operation which lends itself to alteration will be described presently.

The patient is admitted to the hospital the evening prior to operation or if the operation is to be performed in the afternoon he is admitted in the morning of the day of operation. He should not eat breakfast however. Several enemas of soapuds or saline solution administered through an 18 F catheter instead of a hard rubber enema tip will provide a field sufficiently clean and free from unneccesary trauma or irritation. Sedatives and other preoperative medication will vary with the type of anesthesia to be employed. Several types of anesthesia can be used in order of value with regard to their safety and the resultant re-

laxation and lack of distortion they are as follows: sacral low spinal infiltration and general or inhalation.

The best exposure of the operative field is obtained by placing the patient prone with the hips slightly elevated by means of a padded kidney rest or transverse bar. The surgeon and the second assistant operate from the patient's left side and the first assistant operates from the patient's right. After anesthesia has been induced the shaved skin of the perianal, gluteal, sacrococcygeal and perineal regions is treated with an antiseptic solution such as tincture of metaphen and a handful of fluffed gauze is placed over the perineum.

Careful digital examination is performed in order to detect any abnormalities which may have escaped previous notice. If anal contraction is discovered the anus is dilated gently to admit two fingers. A large Hirschman ano-cope is then inserted into the anus, the obturator is withdrawn and after the removal of any feces, mucus or water that may be present a gauze sponge is placed in the rectum by means of an 8 inch (20 cm) dressing forceps. Three gauze sponges are then introduced through the ano-cope by means of the dressing forceps and the ano-cope is removed over the forceps while the grasp on the sponge is maintained. After the ano-cope is withdrawn the gauze sponges are slowly pulled outward partially through the anus. The bulk of the gauze should be sufficient to obstruct the venous flow and thereby to cause distention of the internal and external hemorrhoids. The operation is actually planned as this distention reaches its maximum. With the hemorrhoids distended it usually can be decided whether to take them out in four, three or two groups by the amputation of one side by the amputation of the entire circumference of the anus by dividing it into right and left halves or by complete amputation of the anal circumference (a cuff). The decision depends on the surgeon's judgment and experience.

The surgical objective is to remove the hemorrhoids and to restore the relationship of the mucous membrane and skin so that when healing is complete distortion will not result. The fibers of the external sphincter provide an unusual landmark for the ex-

ternal hemorrhoid is removed so that the muscle is exposed and forms the base of the wound the surgeon can be certain that he has removed all of it. Also if the edge of the wound in the mucosa resulting from the excision of the internal hemorrhoid is drawn outward and sutured circumferentially to the inner fibers of the sphincter the normal relationship of skin and mucous membrane will be reestablished after healing is complete.

To remove a comparatively small internal-external hemorrhoid a  $6\frac{1}{4}$  inch (16 cm) Mayo-Ochsner clamp is placed in the normal skin at the lateral extremity of the ex-

ternal hemorrhoid. Dissection is started laterally between the tenaculum and the lateral clamp and is continued medially to between the medial clamp and the ligature. If as the dissection is started the surgeon makes sure that the fibers of the sphincter form the base of the wound that he is producing the dissection usually progresses easily.

After excision is completed the mucosal stump encircled by the ligature is drawn outward to the level of the proximal fibers of the external sphincter and two half Lambert sutures one on either side of the stump are passed first through the mucosa and then through a few of the fibers of the ex-

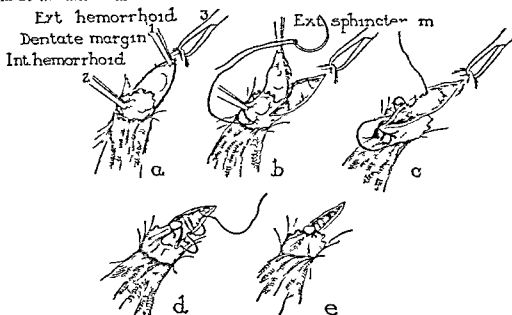


Fig 584 Steps in the removal of internal and external hemorrhoid. a clamps 1, 2 and 3 in place used on marked b dissection begun c dissection completed half Lambert suture on one side begun, d mucosa retracted other half Lambert suture begun e operation completed (Gauze in b, c, d and e for illustrative purposes only)

ternal hemorrhoid and another similar clamp 0.5 to 1 cm above the internal hemorrhoid (Fig 584 a). A tenaculum is then placed lateral to the first clamp and sufficiently deeply so that it may be employed as a retractor. The three gauze sponges are then removed from the anus and with a no. 3 Mayo taper point curved needle a double tie of no. 1 plain catgut is placed internal to the clamp (Fig 584 b) in the normal mucous membrane. The suture is tied so that there is one long end. The tenaculum and the suture provide the means of retracting and fixing the tissue to be removed (Fig 584 b) and the Mayo Ochsner clamps are employed to manipulate the hemorrhoidal tissue as it

is being removed. Dissection is started laterally between the tenaculum and the lateral clamp and is continued medially to between the medial clamp and the ligature. If as the dissection is started the surgeon makes sure that the fibers of the sphincter form the base of the wound that he is producing the dissection usually progresses easily. After excision is completed the mucosal stump encircled by the ligature is drawn outward to the level of the proximal fibers of the external sphincter and two half Lambert sutures one on either side of the stump are passed first through the mucosa and then through a few of the fibers of the ex-

posed sphincter (Fig 584 c and d). If the sutures are properly employed the mucosal stump and the adjacent margins of the wound in the mucous membrane will be situated at the level of the inner fibers of the external sphincter (Fig 584 d and e). It may be necessary to insert one or two sutures for hemostasis. After one hemorrhoid is removed three more gauze sponges are inserted into the rectum and the process is repeated or adjusted to provide for the same factors: removal of the other hemorrhoids or associated pathologic processes.

The technic as outlined may be varied greatly especially if the surgeon will notice that an irregularly diamond shaped wound

is produced when the excision is completed. The two medial sides in the mucosa may be retracted and so sutured that the diamond may be altered to produce a triangular wound with the elongated base of the triangle formed by the mucosal edge sutured to the internal fibers of the external sphincter. The other two sides of the triangle will be formed by the cutaneous margins of the wound. Several clamps can be used in the mucosa to mark the internal limit of the excision and to provide traction or hemostasis. Several more clamps can be used in the skin to provide easy manipulation of larger hemorrhoidal masses. The first double tie can be placed so that the mucosal stump will be posterior to the midpoint of the incision in the mucosa and the resulting mucosal edge can be sutured to the internal fibers of the external sphincter by means of a continuous locked suture using the long end of the tied suture. If clamps are used to mark the internal limit of the region to be excised then before the dissection is started the suture may be placed posterior to the margin of the hemorrhoid sufficiently deep so as to catch the fibers of the external sphincter. The suture is tied with a long end. This procedure will insure more accurate placement and will expedite suturing since this much will be accomplished before bleeding occurs. If clamps are used dissection may be completed and the mucosal edge retracted and sutured to the internal fibers of the external sphincter by interrupted half Lambert sutures.

At the time that the mucosal edge is sutured to the sphincter two factors must be observed closely. 1. The mucosa must not be drawn too far outward for an ectropion of mucous membrane will result. 2. The mucosal edge must not be sutured to the internal edge of a partially everted external sphincter for if this is done then after normal muscle tone returns an overhanging edge or shelf will be produced which may cause an abscess during convalescence. Both of these errors can be avoided by close observation. It is important also that sufficient skin be removed to permit ample drainage of the wound.

**Postoperative Care**—The care of the patient and the wounds after operation is important. At the completion of the opera-

tion a soft gutta percha drain 3 or 4 inches (8 or 10 cm) long is inserted into the anus on both sides of this drain several strips of 2 inch (5 cm) petrolatum gauze are placed which are removed in from eighteen to forty eight hours. After the patient has returned to his room his pulse rate should be observed every half hour for eight hours. A sixth to a quarter grain (0.01 to 0.16 Gm) of morphine sulfate is administered hypodermically as required until the acute pain has subsided. As soon as the anesthesia has disappeared either hot or cold moist packs may be applied. The postoperative perianal injection of solutions producing prolonged anesthesia frequently causes rather spectacular results but the method is not free from risk.

The patient may experience difficulty in voiding but if assisted he may be permitted to stand beside his bed or even go to the bathroom. All efforts should be exercised to obtain normal daily stools. The diet may be altered if necessary but about five to seven days will be required to establish this regulation. After each evacuation the anus and wounds should be irrigated with warm water (approximately 110° F) by means of an 18 F catheter attached to an enema bag. Hot, moist packs should be applied for from four to six hours daily until most of the soreness has subsided. The patient may be permitted to be up for increasing periods after forty eight hours has elapsed postoperatively. It is advisable for the patient to stay in the hospital until the sutures have been absorbed or removed. Bleeding tends to occur most frequently from the eighth to the tenth day after operation. The wounds should be closely examined daily for any abnormalities irrigated with witch hazel and treated with a non irritating anti septic such as an aqueous solution of metaphen. Alert observation to detect complications promptly and to care for each patient's problems sympathetically will be repaid by sincere gratitude and appreciation.

NEWTON D. SMITH

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## CARCINOMA OF THE RECTUM AND ANAL CANAL

Whether carcinoma of the rectum is becoming more prevalent or the clinician is becoming more skillful in the use of modern means of diagnosis is a matter of speculation but certainly the disease is being recognized more frequently than ever before. Next to the stomach the rectum is the most common site in the gastrointestinal tract for malignant disease. In 3410 cases of malig-

sibility in acquiring a full knowledge of the characteristics of this disease so that they can make earlier diagnoses and promptly institute suitable treatment. In too many instances the patient has been subjected to hemorrhoidectomy after the onset of symptoms of carcinoma. This occurred in 98 per cent of a large group of cases observed by the writers.

Men are affected more commonly than women in the ratio of about three to two. In the writers series of cases the average age was fifty-seven years; most of the patients were between forty and seventy years of age. However, young persons often have the disease. Rankin and Comfort reported that the incidence of carcinoma of the rectum of persons aged thirty or less in a series of over 2000 cases was 3.85 per cent. Cancer of the different parts of the digestive tract in the young has been exhaustively reviewed by Jordan and Chamberlin.

**Etiology.**—Surmises as to the etiological factors involved in the production of carcinoma are perhaps frequently unwise or ill timed but unquestionably it is possible to trace certain frequently found lesions in the rectum and large bowel through the different stages of their malignant metamorphosis (Fig 58a). This is particularly referable to the changes which are seen in multiple or single polyps which are so frequently found in an otherwise normal bowel. This subject is considered in greater detail in the chapter on carcinoma of the colon.

It is the opinion of Fwing Pennington Jones and the writers that carcinoma of the rectum does not develop as a result of benign lesions such as anal fissure, ulcerative proctitis, hemorrhoids and strictures. Rosser on the other hand considers that these lesions are precursors of carcinoma. Constipation as an etiologic factor is of little significance. Pennington made the pertinent observation that constipation is notoriously more common in women yet the incidence of carcinoma of the rectum in this sex is less than in men and as DuPan has pointed out the anus which is the portion of the rectum most liable to become irritated by the passage of feces is the most infrequent site of carcinoma.

**Pathology.**—There is considerable controversy among proctologists as to the fre-

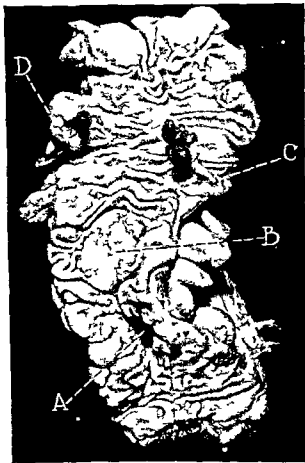


Fig 58a.—Resected specimen of the rectum and sigmoid. A and B Adenocarcinoma grade 4. C and D polyps involved in an adenocarcinoma grade 4.

quency of the large intestine in which operation was performed at the Mayo Clinic from 1907 through 1938 9259 or 63.48 per cent of the lesions occurred in the anus, rectum and rectosigmoid. This high incidence in the rectum should impress the clinician and surgeon of their grave respon-

\* Rankin, Bergen and Buc: *Colon, Rectum and Anus*. W. B. Saunders Co. Publisher.

quency with which carcinoma occurs in the various segments of the rectum. The writers believe that most carcinomas of the rectum are at the rectosigmoid juncture that the next point of frequency is in the ampulla of the rectum and that the site of least frequency is the anal canal and the lower 5 to 7 cm. of the rectum. Growths at the rectosigmoid juncture have a tendency in many instances to prolapse into the ampullary portion of the rectum and in this manner mislead the proctologist in determining the true location of the growth. The anterior and posterior walls appear to be more often affected than the lateral wall.

The usual type of growth, excluding the anal canal, is an adenocarcinoma. Various classifications have been given to carcinoma of the rectum, some based on clinical ground, others on histologic grounds and still others representing a combination of both. All carcinomas of the rectum however develop from crypts or glands of Lieberkuhn and those originating in the anal canal are true squamous cell carcinomas. Of considerably more significance than the classification of carcinoma of the rectum on clinical grounds or according to physical attributes of the invading growth is a microscope grading of the neoplasm on the basis of cell differentiation as has been described by Broders. In a study of 2000 epitheliomas 1628 of which were of the squamous cell type Broders classified them into four groups according to differentiation and mitosis. The more nearly the cell approaches the embryonic or undifferentiated type the more malignant the tumor and conversely the more nearly normal the tumor cell the lower the grade of malignancy. The grading was made on a basis of 1 to 4 and entirely independent of the clinical history. This work was substantiated by Martzloff in 1923 by Greenough in 1925 and by Dukes and Gabriel in England and many others in this country.

Approximately 5 per cent of carcinomas of the rectum are of the mucoid or colloid type. A detailed consideration of this type of carcinoma may be found in the section on the colon. Epitheliomas originate in the anal epidermis and are in most instances highly malignant. Such growths are comparatively rare. Metastasis occurs early and

by the way of the inguinal nodes rather than upward toward the retroperitoneal nodes as is the case when the growth is situated above the anal canal.

Three methods of extension through the lymphatics are described by Miles: (1) downward into the wall of the bowel below the growth into the rectal sphincter and ischiorectal fossa; (2) laterally into the fascia propria, levator ani muscles, capsule of the prostate gland, seminal vesicles and base of the bladder in the male and the vaginal wall and genitalia in the female; or (3)

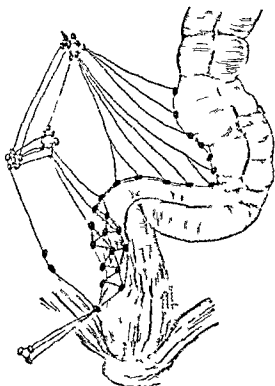


Fig. 586.—Extramural lymphatic structures of the rectum and rectosigmoid. (After Miles from Rankin, Dargen and Bie.)

upward into the bowel above the growth and the pelvic peritoneum and mesocolon (Fig. 586). If remote metastasis occurs the liver is usually affected first. Rectal carcinoma may reach this organ through glandular metastasis or by the breaking off of emboli of carcinoma cells into the portal circulation. McVay, Rankin and Olson, Gabriel, Dukes and Bussey, and Gilchrist and David have shown that the size of the growth in the rectum cannot be relied on as an accurate index to the probable lymphatic involvement and that the growths without

lymphatic involvement tend to grow into the lumen of the bowel

**Symptoms**—Renal complaints are notably undependable symptoms produced by carcinoma of the rectum or colon will often be found to vary widely in different cases and any of them may be produced by other rectal or intestinal disorders. Unfortunately early diagnosis cannot be made from any definite line of symptoms and the symptoms which may be considered as suggestive are not uniform but occur in enough instances to stress the importance of making an examination if there is any evidence of irregularity of bowel habits. The alertness of the clinician in urging this type of examination and referring the patient for treatment will increase the good results of removal by allowing treatment to be undertaken at a less advanced stage of the disease. Commonly symptoms have persisted for a considerable time before the patient comes to operation. The average duration of symptoms in cases of carcinoma of the rectum is approximately eleven months.

Unquestionably the most frequently encountered symptoms and signs of carcinoma of the rectum none of which is pathognomonic or distinctive are bleeding, irregularity of stool and pain in the order named.

**Bleeding**—The most constant sign of a malignant condition of the rectum in the writer's experience has been bright blood which in some cases was mixed with the stool and in others simply streaked the stool. Moreover it is probably one of the earliest manifestations of carcinoma of the rectum. Of 1937 patients with carcinoma of the rectum and sigmoid treated in the Mayo Clinic from 1910 to 1922 there was a history of bleeding in 84 per cent. The average hemoglobin value however was 72 per cent showing that anemia with carcinoma of the rectum except when the disease is far advanced and metastasis has occurred is not as common as it is with carcinoma of the right segment of the colon.

**Irregularity of the Habit of Going to Stool**—Change of bowel habit or irregularity of the large bowel however slight if it persists should indicate the necessity for a thorough examination of the gastrointestinal tract. In a series of 539 cases reported

by Rankin constipation was the predominant complaint in 332 cases (55 per cent) and in 20 per cent diarrhea was the most prominent manifestation. The diarrhea varied from that indicating a mild irritability of the bowel evidence of which was elicited only on close questioning to the passage of eight or ten stools daily. Usually the diarrhea does not alarm the patient until dehydration or weakness from the loss of fluid is apparent. In the cases in which constipation was the predominant symptom marked variation was observed in its description; some patients considered constipation as it is usually conceived as a normal state and realized that obstruction was present only when the use of drastic purgatives failed to bring relief or when associated signs and symptoms such as pain or blood in the stool developed.

**Pain**—Pain is an untrustworthy symptom present in some cases absent in others excessive at times or of moderate severity. It has little if any relation to the presence of the growth until the neoplasm has extended beyond its local confines or has fastened itself to some viscus or nerve trunk where its irritation constantly calls attention to its presence. Because the rectum is not endowed with pain sensation the physician is deprived of one of the most valuable aids in identifying a malignant lesion of the rectum in its earliest stages.

**Excessive loss of weight or strength** symptoms which are so frequently recorded in textbooks as indicative of carcinoma of the rectum are worthless in the early recognition of the condition since they indicate metastasis to distant organs in most cases. Loss of weight is not usually appreciable until late in the course of the disease. In fact most patients are in such apparent good health in spite of a long history and advanced lesions that one might think of the robust person as the type subject to neoplasia of the rectum.

**Involvement of adjacent organs and structures** such as the prostate gland, vagina, urinary bladder, uterus or sacrum produces symptoms referable to disease of those structures and secondary infection in perirectal growth not infrequently leads to ischio-rectal abscesses and fistulas.

**Diagnosis**—Digital examination although important should never be considered conclusive. Many of the lesions which involve the rectum, rectosigmoid and sigmoid flexure are above the reach of the index finger during the ordinary digital examination and the only satisfactory way to search for these pathologic conditions is by the visual method using the proctoscope and sigmoidoscope.

The appearance of carcinoma of the rectum, rectosigmoid or sigmoid flexure is so characteristic that it should rarely be confusing even to those who have had relatively little experience in making proctoscopic examinations. Such lesions once seen should not and hardly can be forgotten. In the first place any single lesion whether an excavating ulcer or a proliferating mass should be regarded with suspicion. The fact that the lesion is single is in itself almost pathognomonic of carcinoma since almost any other lesion encountered there will be associated with some inflammatory reaction and when inflammation and infection are present a single lesion is rarely found. It is a peculiar characteristic of carcinoma that adjacent tissues appear unusually normal. Polypoid growths may possess all the characteristics mentioned but they should always be considered to be potentially malignant (Fig 585).

Since a lesion which is operable from every point of view must be considered inoperable at times because of its excessively malignant cellular structure specimens should be taken as a routine procedure or if not routinely certainly when there is doubt as to the true nature of a lesion. It should be remembered that a positive report on microscopic examination is conclusive but a negative report is not for it may mean that the specimen was not taken deeply enough or from the proper place and a second section may prove the error.

**Treatment**—Usually operation is considered the treatment of election in most cases of operable carcinoma of the rectum, rectosigmoid and anus. For lesions of the anus alone an appreciable number of surgeons will choose treatment by irradiation in preference to operative measures particularly for epitheliomas grades 3 and 4.

**Operability and Prognosis**—Operability implies the consideration of all conditions favorable and unfavorable to the removal of carcinomatous growths. Conditions which in border line cases must be measured and evaluated according to the judgment, experience and courage of the surgeon. The standard of operability has gradually improved with the refinement of surgical technique and the development of greater skill by individual surgeons. Operability and prognosis have been determined by such modifying influences as age, sex, obesity, general health, duration of the lesion with its attendant signs and symptoms and various local conditions associated with the neoplasm such as size, situation and mobility, the relative malignancy and the presence or absence of metastasis both lymphatic and visceral. A detailed consideration of these factors which apply equally to the colon and rectum may be found in the section on Carcinoma of the Colon.

The index of malignancy applied to biopsy obtained from rectal neoplasms is of value in judging inoperability in certain cases. Rankin and Broders have shown that the grade of the malignancy has a direct bearing on the percentage of metastasis and absence of metastasis since the percentage of patients with metastasis increases in proportion to the grade and the percentage of patients without metastasis increases in inverse proportion to it. The following analysis of 853 cases of cancer of the large bowel strikingly demonstrates that the degree of malignancy materially affects the prognosis.

CANCER OF THE LARGE BOWEL

With glandular involvement (397 cases)	Grade 1	Grade 2	Grade 3	Grade 4
Incidence	9%	31%	28%	32%
Five year cures	44%	34%	18%	15%
Without glandular involvement (466 cases)	Grade 1	Grade 2	Grade 3	Grade 4
Incidence	16%	60%	16%	6%
Five year cures	69%	56%	40%	37%

In 1937 Dukes of St Mark's Hospital (London) reported that he had graded 600 cases of cancer of the rectum and had reached the conclusion that if tumors are graded by Broders' method the after history will show that there is a distinct difference in the survival rate according to the grade. A study of 200 cases graded more than five years previously revealed the following death rates from metastasis: 40 per cent for grade 1, 56 per cent for grade 2, 76 per cent for grade 3 and 100 per cent for grade 4.

Gilchrist and David reached the following conclusions from an analysis of the specimens studied in their series. The size of the tumor is of little value in determining the presence or absence of lymph node metastasis. Low lying tumors may have metastasis very high. If the upward lymph channels are blocked by metastasis there may be a retrograde metastasis downward. When the tumor is found at the level of the levator ani muscle the lymphatic drainage may be lateral as well as upward. Similarly squamous cell carcinomas which involve the mucosa have a double lymphatic drainage consequently a radical resection of the rectum is indicated when this occurs. Tumors having lymph node metastases tend to be of a higher classification according to Broders grading than those without metastases. Finally they concluded on the basis of the foregoing findings that radical removal of the rectum and distal end of the sigmoid with resection of the superior hemorrhoidal artery as high as possible and wide resection of the levator ani muscles is necessary in order to give the best chance of permanent cure. The Miles type of operation in their opinion has fulfilled these requirements.

The operability and prognosis also depend on the presence and extent of lymphatic metastasis. Extensive investigations along these lines reported by Gabriel Dukes and Bussey (1935) and Gilchrist and David (1938) have been highly illuminating. Grossly the appearance of a lymph node may be entirely normal and yet microscopic section will reveal a malignant growth. On the other hand large lymphatic structures which are hard to touch and give an impression of malignant tissue are frequently

found to be inflammatory. Gabriel Dukes and Bussey reported that in a series of 1242 nodes removed from peritumoral specimens 905 were considered from gross appearance to be free from metastasis yet microscopic study showed that 18 were cancerous in error of 2 per cent. On the other hand of 337 nodes which were thought from their gross characteristics to be cancerous metastasis was present actually in only 192. Gilchrist and David in a similar study of 496 nodes reported that of the 111 lymph nodes containing carcinoma only 48 showed any gross change even in cross section of the gland. Their study further revealed that 68 per cent of their operatively removed specimens of carcinoma of the rectum showed metastasis to lymph nodes.

Until more adequate therapeutic agents than operation offer greater opportunities for cure or palliation to sufferers from carcinoma radical extirpation undoubtedly is justified in all cases up to and frequently including those of borderline operability. Certainly only a little is lost and perhaps much is gained if a questionable growth is extirpated.

**Choice of Operation.**—It is difficult to make a dogmatic choice of an operation for carcinoma of the rectum. It is not probable that any one procedure will ever be applicable to all types of carcinoma of the rectum and rectosigmoid for the reason that patients present themselves at such varying stages of the disease and consequently in such different physical states as regards both metastasis and local extension of the growth and because the lymphatic drainage from different divisions of the terminal bowel is by widely divergent channels. Therefore any surgeon who operates on patients with carcinoma of the rectum should have at his command a number of procedures and should make the selection that seems wisest in each case for example colostomy and perineal excision, abdominoperineal resection in one stage, abdominoperineal resection in two stages and palliative operations such as colostomy and local cauterization. The employment of one operation to the exclusion of all others decidedly narrows the scope of usefulness which surgical treatment offers to these sufferers and unquestionably vitally influences the immediate mortality.

the functional results and the ultimate survival.

The following analysis of the experience of one of us (Rankin) shows the variety of procedures employed and the tendency toward more frequent performance of the radical abdominoperineal operation of Miles.

#### CANCER OF THE RECTUM AND RECTOSIGMOID

	Cases	Deaths
One stage abdominoperineal resection	136	9
Two stage abdominoperineal resection	7	0
Colostomy and posterior resection	49	4
Posterior resection	1	0
Radium	4	0

#### Palliative Procedures

Colostomy alone or with		
Exploration	52	8
Exploration alone	10	0
Cecostomy	3	1
	<u>65</u>	<u>9</u>

Colostomy with perineal excision has had its greatest popularity in England and America and is practiced to a less extent in France and is hardly ever practiced in central Europe. Miles abandoned this method of procedure in favor of the more radical combined abdominoperineal operation which bears his name. Lockhart Mummery, on the other hand, prefers perineal excision to all other methods and contends that the actual difference between the amount of tissue removed by this operation and by the abdominoperineal route is so slight as to make no difference as regards recurrence provided the lesion is situated below the rectosigmoid junction. This, however, has not been the opinion of the majority of those who have had considerable experience with the surgical treatment of carcinoma of the rectum. Distinctly, it has not been the writers' opinion.

In order to avoid the objections to many of the proposed operative procedures and to preserve the desirable features of the single stage operation, various two stage procedures based on the abdominoperineal principle have been devised. These including the perineoabdominal resection of Rankin and a similar procedure of Iahey have in the opinion of the writers a very limited applicability. As one's experience with the Miles procedure increases the tendency to resort

to the less satisfactory two stage operations decidedly diminishes.

Along with an overwhelming majority of those surgeons both in this country and England who are particularly interested in the treatment of carcinoma of the rectum we feel that the occasional success which attends interior resection of the rectosigmoid with restoration of bowel continuity does not counterbalance the greatly increased morbidity and recurrence mortality as contrasted with adoption of permanent colostomy in all but highly selected cases.

Sacral operations have rarely been employed in this country or in England in the last decade but on the continent particularly in Germany and Austria the sacral route has been used almost to the complete exclusion of all other maneuvers. The operative and the recurrent mortality together with the percentages of poor functional results have been excessively high.

Colostomy is regarded as of the greatest value as a palliative procedure. However, there is some difference of opinion in regard to the employment of colostomy for inoperable carcinomas of the rectum. At present, however, there are few surgeons who are unalterably opposed to colostomy as a palliative procedure. Its urgent need in the presence of complete obstruction is universally conceded its justification previous to this stage is challenged by a few. Since in most instances operability is not determined until the abdomen has been explored, it would appear that the logical time for establishing colostomy would be at the initial operation when inoperability is determined. The absence of obstructive symptoms is of little significance and rarely should influence postponement of colostomy, since in most instances some degree of obstruction will eventually develop. In the event that the obstruction is acute owing to a sudden blockage of the lumen in instances of annular lesions and unrelieved by medical measures blind cecostomy rather than colostomy is indicated. A detailed consideration of decompressive measures may be found in the section on carcinoma of the colon.

The status of radium and roentgen rays in cases of carcinoma of the rectum is not well defined. Many who have had consider-

able experience with irradiation consider that it must be regarded as being still in the experimental stage. Certainly one can expect little more than palliation when roentgen therapy is employed for rectal carcinoma.

**Operative Procedures**—The acceptance of the postulate that all carcinomas that can be extirpated should be dealt with radically, not alone by their removal but by removal of the contiguous gland bearing tissues as

neum are removed. All subsequent surgical developments in this direction have been based on the principles of the Miles operation.

**Miles Operation**—Through a low midline incision the abdomen is opened and after exploration of the liver and lymphatic structures for metastasis the sigmoid flexure is isolated. The peritoneum is incised on both sides of the bowel and in front of the bladder in order to insure adequate mobilization.

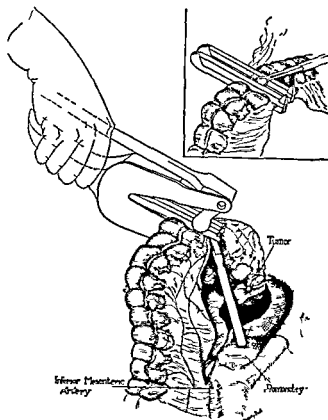


Fig. 587—Abdominal operation for excision of rectum (Miles) employing Cope clamp. Crushing force is applied to the distal end of the bowel segments until each is locked by a special catch. After removal of the cruler the middle segment of the clamps is unlocked and removed and the exposed thin lamella of crushed bowel is sealed by the cautery (insert).\*

well predicates a formidable procedure in dealing with carcinoma in this region. The lymphatic drainage involved in carcinomas of the rectum that are above the anal canal has been excellently worked out by Miles who in addition to these pathologic studies has contributed to the technical perfection of a radical combined abdominal-perineal procedure in which the growth and all the regional nodes of the pelvic floor and peri-

neum are removed. All subsequent surgical developments in this direction have been based on the principles of the Miles operation. The sigmoid is further freed by blunt dissection into the hollow of the sacrum. All tissues including fat and lymphatic vessels in this region and on both sides of the bowel up to the base of the inferior mesenteric vessels are freed by blunt dissection. The bowel is then divided between clamps at a point where the blood supply is adequate

\*Rankin and Graham: Cancer of the Colon and Rectum. Charles C. Thomas, Publisher.

and the proximal end is delivered through a small left inguinal wound to form a single barreled colostomy the distal end is inverted and dropped into the pelvic cavity, after which a new pelvic floor is formed by approximation of the lateral peritoneal flaps. The abdomen is closed without drainage.

The resection in our opinion is facilitated by the employment of the Cope clamp (Fig 87) which simplifies division of the bowel particularly when there is present considerable adipose tissue and obviates the necessity of inverting the distal end of the sig-

moid operation described here allows one to perform a radical operation when the patient's condition is so debilitated and undermined that a single stage operation would be attended by a prohibitive mortality and the only other choice would be a colostomy and subsequent posterior resection. It is particularly applicable in the less sturdy risks when the growth is situated at the rectosigmoid. In our opinion however neither this procedure nor Lahey's modification of it should be employed if appraisal of the patient's condition would seem to warrant the

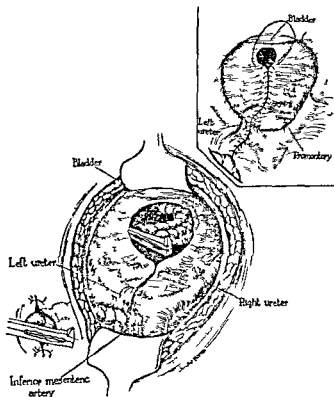


Fig 88—Abdominoperineal excision of the rectum (Miles) employing Cope clamp. The long segment of the proximal end of divided bowel is pushed lengthwise through a small stab wound in the left iliac region to establish a single-barreled colostomy; the distal end of the bowel with its attached segment is pushed down below the pelvic peritoneum and a new pelvic floor is established (Curtis).

moid thus diminishing the opportunity for contamination.

The patient is then turned on his side or on the abdomen with the hips elevated. The anus is closed with a purse-string suture. Lateral incisions are made and dissection about the rectum is carried out all just as in a posterior resection. There is very little bleeding because of ligation of the inferior mesenteric artery. The rectum together with the retroperitonealized sigmoid is extirpated with rapidity and ease.

**Ranlin Operation (1)**—The two stage

one stage maneuver.

Colostomy and exploration are carried out at the first stage and consist in dividing the bowel establishing a single-barreled colostomy as in the Miles operation and dropping the inverted rectal end back into the peritoneal cavity, closing the abdomen and then waiting a period of at least three weeks before radical removal of the isolated segment which is accomplished by a combined abdominoperineal operation. Rectal irrigation.

\* Baile and Graham. Cancer of the Colon and Rectum. Charles C Thomas Publisher.



tions are carried out between stages. In the second stage the patient is placed on the operating table as for posterior resection of the rectum and the rectum is mobilized up to the peritoneum also as in the latter procedure and encased in a rubber glove which is tied tightly about the cuff. This is pushed up into the hollow of the sacrum and the wound is then closed.

Next the patient is placed on his back and the anterior portion of the dissection is carried out. The peritoneum is incised on both sides of the previously divided sigmoid; the inferior mesenteric vessels are ligated

procedure which retains the principles of the radical abdominoperineal operation is considerably less formidable than either the Miles operation or the preceding one of which it is a modification. At the first stage abdominal exploration is carried out through a right split muscle incision and a cecostomy is established (Fig. 579). The second stage consists of a perineoabdominal operation. First the rectum is mobilized and enclosed in a rubber glove; the patient is then turned over and the abdomen is opened. A single-barreled colostomy is then established as previously described except that

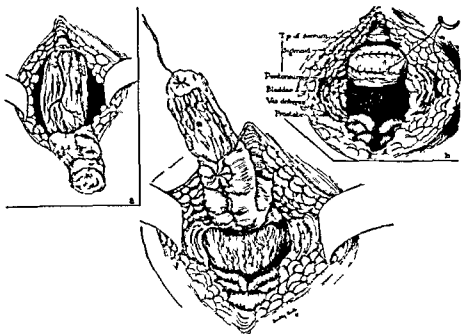


Fig. 580—Penneal excision of the rectum. The anterior portion of the dissection has been carried down to the membranous urethra and the prostate gland and seminal vesicles are slowly dissected clear. Peritoneum is opened to permit further mobilization of the sigmoid after division of the superior mesenteric vessels (insert a). Insert b shows the end of sigmoid inverted and the peritoneum being sutured at a higher level to the sigmoid. (Adapted from Rankin and Graham\*.)

close to their origin the rectosigmoid is freed by blunt dissection in the hollow of the sacrum; the rubber glove is grasped and the entire segment of sigmoid, rectum and anus is lifted out of the abdomen. The gauze pack is inserted into the large cavity thus opened to be removed later through the posterior wound. A new pelvic floor is established by approximation of the lateral peritoneal flaps and the abdominal wound is closed without drainage.

**Rankin Operation (2)**—This alternative

\* Rankin and Graham: Cancer of the Colon and Rectum. Charles C. Thomas Publisher.

it is unnecessary to invert the rectal end. The remainder of the procedure is identical with the preceding one. The freed sigmoid and rectum are lifted out of the hollow of the sacrum and a new pelvic floor is made; the abdomen is then closed without drainage. This operation permits fully as radical a resection as the Miles operation in one stage yet it has a mortality no greater than that of posterior resection.

**Colostomy and Posterior Resection (Perineal Incision)**—A double-barreled colostomy is first established and two or three weeks later the resection is carried out. The

writers prefer the left inguinal colostomy, a description of which is given in detail in the section on carcinoma of the colon (Fig 579). For the posterior resection the patient lies prone with the hips elevated. A purse string suture is placed about the anus, two elliptical incisions are made to extend from a little above the sacrococcygeal joint around to the center of the perineum. The coccyx may or may not be removed as seems best in each case.

The rectum is freed (1) of its attachments posteriorly by blunt dissection in the hollow of the sacrum (2) of its lateral attachments by extending the original incisions down through the levator ani muscles and lateral ligaments which contain the medial hemorrhoid vessels and (3) of its anterior attachments by traction on the distal end of the bowel as sharp dissection is carried upward to the reflection of the peritoneum in the female and to the capsule of the prostate and seminal vesicles in the male (Fig 589). The peritoneal cavity is entered, sufficient sigmoid is pulled down to enable resuture of the peritoneum 3 to 7 cm above the original point of attachment and the bowel is divided between clamps with a cautery some distance above the growth. The end of the bowel is then inverted and a large rubber dam or oiled silk packed with gauze is placed in the cavity which remains. This provides adequate drainage of serum and temporarily supports the frail perineal floor. In those instances in which the sulfonamides appear to be indicated, dependence is placed on sulfadiazine administered parenterally rather than on local application of these drugs.

**Mortality and Recurrence.**—The mortality following radical and palliative operations on the large bowel contrary to an apparently widespread opinion is not prohibitive nor are fatalities from recurrences so discouragingly numerous as was the case a quarter of a century ago. At about that time barely 25 per cent of the diagnosed cases were operable, 20 to 50 per cent of the patients who were operated on died in the hospital and well over 85 per cent of the survivors eventually succumbed to recurrence. In striking contrast to these results surgeons during the past decade have reported

operability rates as high as 65 per cent for large series of cases while a comparative study of the mortality rate for individual surgeons and institutions by five year and ten year periods has revealed a progressive decline until now the general rate for all types of operations in the hands of experienced surgeons approaches 10 per cent. Moreover the incidence of recurrence as determined for numerous large groups of cases varies from 25 to 50 per cent which is an improvement of from 10 to 60 per cent over the best available figures several decades ago. In other words until relatively recent years fewer than 5 of 100 patients with carcinoma of the large bowel were alive five years after operation whereas now it can reasonably be expected that between 10 and 50 will be living at the end of such a period. As a matter of fact a study of my statistical data indicates that more patients with carcinoma of the large bowel and rectum are found to survive over a given period of years than those with carcinoma of any other portion of the gastrointestinal tract.

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## XXX. THE LIVER AND BILIARY SYSTEM

### THE LIVER

#### INJURIES OF THE LIVER

Injuries of the liver may be divided into (1) penetrating and (2) subcutaneous types the former occurring more frequently than the latter. In a series of reports of 752 cases of injury to the liver collected by Thole 492 were penetrating (292 stab and 200 gunshot) wounds and 260 were subcutaneous injuries. The liver is the most frequently injured abdominal viscus. Of Kruse's 60 cases 83 per cent were due to penetrating wounds (68 per cent gunshot and 15 per cent stab) and 17 per cent were subcutaneous. According to Andersson lesions of the liver and gall bladder occur in 10 per cent of the open and 19.5 per cent of the subcutaneous abdominal injuries. The mechanism of rupture may vary according to the type of injury. Briefly the types are (1) direct trauma to the liver caused by a kick, blow or fall on the abdomen, (2) compression of the liver between a force applied to the abdominal wall and the vertebral column as when a wagon wheel passes over the abdomen, (3) contrecoup injury resulting from a fall on the head or feet and (4) bursting injury as a result of a jack-knifing of the body as occasionally occurs in an infant during delivery (Rogers). Traumatic rupture occurs more frequently in a diseased liver especially one in which there is chronic passive congestion as a result of cardiac failure or one in which there is malignant change. Spontaneous rupture may occur.

**Pathology.**—Subcutaneous injuries to the liver are divided into three types: (1) true ruptures, those in which there is rupture of the capsule and parenchyma of the liver; (2) subcapsular injuries, those in which there is injury of the parenchyma without injury to the overlying capsule; and (3) central ruptures, those in which a localized contusion occurs within the substance of the liver without involvement of the surrounding portion. Subcutaneous injuries espe-

ally true ruptures involve the right lobe most frequently and usually the upper convex surface. True ruptures occur most frequently in the sagittal plane and vary from a small fissure extending only through the capsule to complete division of the liver. Profuse bleeding into the peritoneal cavity is usual. Subcapsular rupture, which also occurs most frequently in the right lobe, is characterized by the tearing of Glisson's capsule from the parenchyma and by the collection of blood between the hepatic substance and the capsule (Vance). Central rupture of the liver occurs as a result of movement of the various cellular layers in the liver caused by bending or torsion of the viscus (Andersson). Because of their similarity to cerebral apoplexy, in which hemorrhage is surrounded by normal brain tissue, these injuries have been designated as apoplexy of the liver (Andersson). A central rupture may increase progressively in size owing to increased pressure and subsequent necrosis of the parenchyma followed in turn by hemorrhage. Infection of a subcapsular and especially of a central rupture of the liver is likely to occur because of the almost constant presence of micro-organisms in the parenchyma of the liver. Hemorrhage in a true rupture is more likely to continue and to be severe than in the subcapsular or the central type. In spite of the low vascular pressure in the portal system hemorrhage from the liver tends to continue because the portal radicals in the liver have thin walls, contain few elastic fibers and have no valves (Alessandri). Bleeding is prolonged and coagulation delayed because of the massaging action of the respiratory movements and the admixture of bile with the blood. In all types of trauma to the liver there is injury of the parenchyma and tearing of the bile ducts. In a penetrating or subcutaneous true rupture of the liver bile escapes into the peritoneal cavity, varying in quantity from a relatively small amount to several liters.

**Symptomatology.**—The principal symptoms in injury of the liver are dependent on

hemorrhage from the liver which is most evident in a penetrating wound. The first manifestation of injury is shock from which the patient may recover temporarily unless there is massive hemorrhage. Irrationality, vomiting and irritability were present in 21.18 and 11 per cent respectively of Krieg's cases. Profound anemia develops. The pulse rate may or may not be increased. As a result of the escape of blood and bile into the peritoneal cavity in a case of penetrating or subcutaneous rupture there is an increase in the amount of peritoneal fluid as evidenced by dullness in the flanks. A fullness is palpable in the cul-de-sac of Douglas on rectal or vaginal examination. Bradycardia due to absorption of bile salts when present is of diagnostic importance and is contrasted with the tachycardia usually accompanying severe loss of blood (Finsterer). Bradycardia is found relatively infrequently and its absence is of no clinical significance. Pain in the upper right abdominal quadrant which is likely to be referred to the right shoulder is frequent. Tenderness and muscular rigidity especially marked along the right costal margin are prominent signs. The temperature at first is subnormal but later is elevated. Examination of the blood shows progressive anemia and increasing leukocytosis indicative of hemorrhage. As a result of absorption of bile salts from the peritoneum or from the liver itself there may be jaundice and in cases in which there is little hemorrhage ecchyma may develop.

**Prognosis.**—The prognosis in injury of the liver depends on the type and the extent of the injury, whether it is penetrating or subcutaneous, the condition of the patient and the time of treatment. The mortality rate in penetrating injuries is lower than in subcutaneous injuries, probably because the former are likely to be recognized earlier. Boljarski reported a 33.3 and a 30.5 per cent mortality rate respectively in stab and gunshot penetrating injuries and an 85.3 per cent mortality rate in subcutaneous injuries. Thole found that in both subcutaneous and penetrating injuries the mortality rate in the first six hours was 39 per cent whereas after twenty-four hours it was 75.4 per cent in the penetrating injuries and 86.3 per cent in the subcutaneous injuries. Boljarski's figures indicate the

value of early operation. His mortality rate for patients operated on within two or three hours after injury was 15 per cent whereas after twenty-four hours it was over 50 per cent. Death occurring within the first twenty-two hours is usually the result of hemorrhage and shock, whereas after the fourth day it is caused by biliary or septic peritonitis. Irrationality, irritability and vomiting are particularly ominous signs. In Krieg's series in which all three manifestations occurred or in which one of the manifestations persisted two days or longer none recovered. Of those showing both irrationality and irritability only 15 per cent recovered.

**Complications.**—The complications of injury of the liver are: (1) massive hemorrhage (hemorrhage and shock were the cause of death in 73 per cent of Krieg's fatal cases); (2) peritonitis either as a result of irritation of the peritoneum by the bile salts (chemical peritonitis) or as a result of the escape of microorganisms into the peritoneum from the bile (biliary and septic peritonitis were the cause of death in 19 and 27 per cent respectively); (3) emboli consisting of pieces of liver; (4) sequestration of the hepatic substance; (5) thrombosis of the portal vein; (6) hepatic suppuration (11 per cent of the pyogenic hepatic abscesses in our series were due to trauma); and (7) rarely acute yellow atrophy (Peter).

**Diagnosis.**—The diagnosis of penetrating injury of the liver is not difficult because the wound directs the physician's attention toward the liver. The diagnosis is more difficult in a case of subcutaneous injury but if in all cases of direct compression trauma of the abdomen as well as in all cases of a fall on the head or feet especially when associated with intra-abdominal hemorrhage the possibility of injury to the liver is considered the diagnosis is not difficult. Progressive hemorrhage as evidenced by the appearance of the patient and the increasing amount of peritoneal fluid especially when associated with bradycardia is suggestive of rupture of the liver. Increasing leukocytosis determined by repeated examination of the blood is indicative of massive hemorrhage and is confirmatory of rupture of an intra-abdominal viscus. Exploratory aspiration of the peritoneal cavity will reveal evidence

of intraperitoneal hemorrhage. Tenderness along the right costal margin is almost invariably found in cases of rupture and is corroborative evidence.

**Treatment**—The treatment of an injury of the liver is primarily surgical. As previously mentioned the progress varies with the length of time between the injury and the operation. Obviously before an operation is performed shock should be combated. In a subcapsular injury hemorrhage is less profuse than in a true rupture. For this reason operation is less urgent than in cases of true rupture and penetrating injuries. However because of the danger of supuration in cases of subcapsular and central ruptures operative exposure and evacuation of the cavity are frequently justified. In cases of penetrating and true ruptures hemostasis must be secured. Preferably this is accomplished by suture of the hepatic substance but because of the friability of the liver this is frequently technically difficult. It can be accomplished by means of suturing very heavy catgut and large blunt needles being used. Hemostasis may be aided by muscle or omental grafts. Tamponade may be necessary in order to secure hemostasis the greatest disadvantage however is the danger of infection. The wound may be cauterized but there is danger of secondary hemorrhage as a result of separation of the eschar. At the time of operation blood and bile should be carefully evacuated from the peritoneal cavity. Since the blood is pirated from the peritoneal cavity should not be introduced into the vascular tree because of its contained toxic substances blood transfusions should be performed early.

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#### PYOGENIC ABSCESS OF THE LIVER

**Etiology**—Pyogenic hepatic abscesses are the result of invasion by pyogenic microorganisms and can occur in the following ways:

1. Transportation of virulent microorganisms through the portal vein from areas drained by the portal system: (a) appendix (11 per cent in our series), (b) rectum and (c) other portions of the bowel.

2. Extension from contiguous structures: (a) gallbladder (6 per cent in our series) and (b) infections of the subphrenic space.

3. Trauma (11 per cent of our cases): (a) penetrating injuries with the introduction of microorganisms from without and (b) subcutaneous injuries producing devitalization of hepatic tissue permitting growth of microorganisms already present in the liver.

4. Blood borne infections with the production of metastatic abscesses, the microorganism being transported through the hepatic arteries.

By far the most frequent antecedent lesion in cases of pyogenic abscess of the liver is suppurative appendicitis with portal thrombophlebitis (pyelophlebitis). In our collected series of 18198 cases of acute appendicitis there were 247 cases associated with hepatic abscess, an incidence of 0.97 per cent. In our series there was an approximate incidence of 0.1 per cent. Eleven per cent of the 47 hepatic abscesses in our series were caused by appendicitis. The microorganisms in pyogenic hepatic abscesses are usually colon bacilli, streptococci and staphylococci (31, 20.6 and 17 per cent respectively in our series). In a large majority of cases the infection begins in the colon where there are defects in the mucosa which permit the penetration of bacteria into the blood stream and their trans-

portation to the liver. These lesions are frequently of such a character that they are not recognized clinically, the hepatic abscess apparently not being preceded by an antecedent lesion: *i. e.* cryptogenic. In our series these cases represented the largest group, 28 of 47 cases (59.5 per cent).

**Pathology.**—In contradistinction to amebic abscess, pyogenic abscess of the liver is usually multiple. Many microorganisms gain entrance to the portal system and are carried to the liver in large quantities. The abscess is more frequently found in the right

sweats. Pain in the upper portion of the abdomen, especially on the right side and referred to the right shoulder is a prominent complaint. In our series fever, pain and tenderness were most frequently encountered, being found in approximately 90 per cent of cases. On physical examination enlargement of the liver and extreme tenderness along the costal margin are noted. The patient appears very ill if the process has persisted long; he is cachectic. Nausea and vomiting, loss of weight and jaundice were observed in one third of our cases. There is

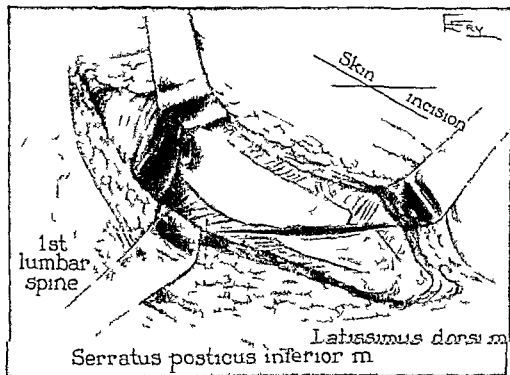


Fig. 590.—Retroperitoneal operation. Drawing showing a transverse incision through the bed of the twelfth rib at the level of the spinous process of the first lumbar vertebra, passing through the attachment of the diaphragm below the reflection of the pleura.\*

lobe of the liver, probably because, as shown by Serjoo, Copher, and Dick, blood from the right half of the colon is carried to the right lobe of the liver. Pathologically, the abscesses vary from those of microscopic size to large coalescing cavities surrounded by a pyogenic membrane. Microscopically, there are the characteristic changes of acute and chronic inflammation. Contained within the abscess cavity is typical pus. Occasionally a pyogenic abscess may be solitary.

**Symptomatology.**—The principal symptoms are fever of a remittent or intermittent type associated with chills and profuse

a marked increase in the number of leukocytes (20,000) with a corresponding increase in the number of polymorphonuclear leukocytes.

**Diagnosis.**—The occurrence of chills and fever, especially when associated with profuse sweats in a patient with suppurative appendicitis or some other suppurative lesion in an area drained by the portal system is indicative of pyelophlebitis and a hepatic abscess until proved otherwise. In contradistinction to amebic abscess of the liver, the

\* Ochsner and Crain: *Ann. Surg.* 59: J. B. Lippincott Co.

leukocyte count is higher and the relative increase in polymorphonuclear leukocytes is greater. Roentgenograms are of value because of the elevation of the diaphragm and the increase in the size of the liver. In contrast to cases of amebic abscess exploratory puncture is never justified because of the danger of contaminating an uninvolved serous cavity.

**Prognosis**—The prognosis in cases of multiple pyogenic hepatic abscess is extremely grave, the mortality rate being approximately 70 per cent. This high rate is due

in the cases in which operation was performed. Furthermore, the type of operative procedure is of prognostic importance as shown by the 33 per cent mortality rate in the cases in which drainage was extraperitoneal in contrast to the 71 per cent mortality in those in which it was transpleural or transperitoneal.

**Complications**—The complications consist principally of rupture of the abscess into the peritoneal and pleural cavities and extension into the systemic blood stream with the development of septicæmia. In our

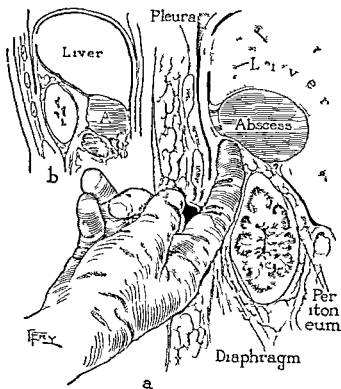


Fig. 591—Drawing showing method of approaching an abscess in the subphrenic space and liver retroperitoneally. The peritoneum is peeled from the undersurface of the diaphragm until the abscess cavity is reached.\*

probably not only to the multiple lesions in the liver which are difficult to recognize and to drain but also to thrombophlebitis of the portal vein which is responsible for continued involvement of the liver. In the case of a solitary pyogenic abscess of the liver the prognosis is not so grave. Ochsner, Gage and Garside were able to collect from the literature reports of 15 cases in which recovery followed operation. The prognosis is dependent to a great extent on the type of therapy instituted. In our series the mortality rate was 100 per cent in the cases in which operation was not performed and 65 per cent

Under no circumstances should a pyogenic hepatic abscess be drained transpleurally because of the danger of contaminating the pleural cavity and thereby greatly increasing the mortality rate (see under the discussion on prognosis). This and contamination of the peritoneal cavity can be obviated by the retroperitoneal operation (Iigs 500 and 501). In those cases in which there is associated pyelophlebitis ligation of the portal vein or its radicals as suggested by Wilms should be done in order to prevent continued discharge of infected emboli into the liver. In cases of multiple abscesses in cision and drainage by the retroperitoneal or extraperitoneal technique should always be carried out but is usually of little avail.

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### AMEBIC ABSCESS OF THE LIVER

Amebic abscess of the liver occurs more frequently than is commonly supposed. Amebiasis which previously was considered a disease of the tropics is ubiquitous and the possibility of hepatic involvement should always be seriously considered. The causative agent of amebic abscess is the *Endamoeba histolytica* and a contributing factor in alcoholism. The incidence of amebic abscess varies considerably. The ratio of the number of patients with amebic abscess to the number with amebic dysentery admitted to the Charity Hospital in New Orleans is 1 to 7.5. Amebic abscesses according to the collected reports occur most frequently in young adults. In our series of

cases 50.3 per cent occurred in patients between the ages of thirty and fifty years. Males are more frequently affected than females. A study of our series disclosed that the ratio of males to females was 8 to 1 but in most reported series the predisposition in males is even greater.

**Pathogenesis.**—The amebas are carried through the portal vein from specific amebic ulcers which may be located in any portion of the large bowel to the liver where specific hepatitis is produced whereas in the majority of cases of amebic dysentery the lesion is principally in the left half of the colon. If the lesion is on the right hepatitis may also occur. In fact hepatitis is more likely to follow right-sided infection as the result of lack of recognition and failure of institution of treatment because of the absence of dysenteric manifestations. Amebic abscess occurs most frequently in the right lobe of the liver probably because as shown by Sérège and by Copler and Dick blood from the right half of the colon passes largely to the right lobe. In a series of 2121 cases collected from reports in the literature the right lobe was found to be involved in 1792 (84.4 per cent) and the left lobe in 329 (15.5 per cent). In the authors' series of 99 cases the abscess was in the right lobe in 95 cases (95.9 per cent) and in the left lobe in 4 cases (4.0 per cent). The higher incidence of involvement of the right lobe in the authors' series is compared with that in the collected cases is explained by the fact that a large number of cases studied at autopsy are included in the latter. Multiple abscesses are usually associated with large extensive intestinal ulceration but a single abscess usually follows less extensive infection. An amebic abscess is usually solitary and is found most frequently in the periphery usually in the diaphragmatic portion of the liver. The amebas produce hepatitis which may subside spontaneously or under treatment or may progress to liquefaction. The latter is largely due to the proteolytic activity of a soluble toxin produced by the amebas (Craig). Rogers has shown that amebic abscess results from extension of the process along the vein from the central cavity and that the original lesion is due to anemic necrosis produced by plugging of the portal radical by the amebas and the lytic



action on hepatic tissue of toxic products elaborated by the amebas. Amebic abscess is characterized by absence of leukocytic infiltration. Characteristically the large abscesses surrounded by fibrous tissue contain the chocolate brown pus the finding of which establishes the diagnosis. In this pus are found few or no leukocytes the material being composed of cellular detritus and blood. The abscesses vary in size from a microscopic to a large solitary abscess filling an entire lobe of the liver. Amebic abscesses are sterile in the majority of instances 84.7 per cent in the collected series and 84.5 per cent in our series. Active amebas are found only in small abscesses but can almost in

stant. Tenderness along the right costal margin and enlargement of the liver occur in approximately 80 per cent of cases. In cases of amebic abscess as emphasized by Rogers and Manson-Bahr there is moderate leukocytosis as contrasted with the marked leukocytosis which is seen in cases of pyogenic hepatic abscess. Characteristically there is not the disproportionate increase in the polymorphonuclear leukocytes that is found in cases of the pyogenic type of abscess. The leukocyte count averages about 15,000 and the polymorphonuclear leukocytes about 80 per cent. A high leukocyte count is indicative of multiple abscesses and offers a bad prognosis (Rogers).

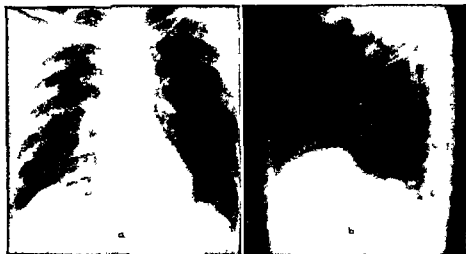


Fig 592—*a* Anteroposterior roentgenogram of the abscess which has ruptured into the subphrenic space *ward into the lower pulmonary field and obliteration of the cost and diaphragm in the same case showing elevation of the anteroposterior angle*

chest and diaphragm of a patient with an hepatic with elevation of the diaphragm localized bulging upward of the cardiophrenic angle *b* Lateral roentgenogram characteristic elevation of the diaphragm and obliteration of the anteroposterior angle

variably be identified in scrapings from the wall of the abscess.

**Symptoms and Signs**—The systemic manifestations of amebic abscess consist of fever, profuse sweating, weakness, anorexia, loss of weight, nausea, vomiting, malaise and chills. Jaundice occurs infrequently. The fever may be of the intermittent or remittent type. A history of diarrhea in a series of 741 collected cases including our cases was present in only 58.2 per cent whereas diarrhea at the time of admission was present in only 21.5 per cent of our cases. Of the local manifestations pain in the upper right abdominal quadrant which may be referred to the right shoulder is the most con-

**Diagnosis**—Of diagnostic importance are elevation and immobilization of the diaphragm as determined roentgenologically. Granger has emphasized that in a case of uncomplicated hepatic abscess a distinct bulging of the diaphragm with a pointing upward into the lower pulmonary field is noted. In those cases in which the abscess has ruptured into the subphrenic space there is obliteration of the cardiophrenic angle in the anteroposterior roentgenogram and there is obliteration of the anterior costophrenic angle in the lateral view (Fig 592 *a*). Amebic hepatitis or an abscess of the liver should be considered when there is persistent enlargement of the liver as oc-

ated with pyrexia and moderate leukocytosis. A history of previous dysentery is confirmatory evidence. The diagnosis can be corroborated by the finding of typical chocolate-brown pus in the material aspirated from the abscess. Aspiration should be done in such a way that the aspirating needle does not traverse a free serous cavity and an immediate smear of the pus should be made in order to eliminate pyogenic infection.

**Prognosis.**—The prognosis in cases of amebic abscess of the liver depends on (1) the multiplicity of lesions in the liver (2) the general resistance of the patient (3) secondary infection of the abscess cavity and (4) the type of treatment employed. Rogers was able to decrease the mortality rate from 68 per cent after open drainage to 14 per cent with closed drainage. Chatterji reports a mortality of 16 per cent after closed drainage. In a series of 4634 case reports collected from the literature and including our own cases in which open operation was performed the mortality rate was 43.8 per cent whereas in a series of 509 cases in which conservative treatment was used the mortality rate was 6.4 per cent. In our series of 198 cases the mortality rate following open drainage was 21.6 per cent in contrast to that of 3.6 per cent following aspiration and the use of amebicides.

**Complications.**—Complications of amebic abscess of the liver are the result of rupture or direct extension into one of the adjacent viscera, secondary inflammation and suppuration, thrombosis and embolism. Pleural and pulmonary involvement are the most frequent complications. Rupture into the pleural cavity and lungs occurs not infrequently. The percentage of cases in which this occurs varies from 3 to 40.8 per cent. This complication occurred in 15.8 per cent of our cases. When rupture into the lung occurs, evacuation of the abscess through the bronchus offers a relatively good prognosis. Other complications include rupture into the peritoneal cavity, into the pericardium, into the abdominal wall with involvement of the abdominal parietes and into the colon. Cerebral abscess and ruptures into the portal vein, inferior vena cava and hepatic veins have been reported but are rare complications.

**Treatment.**—The reduction of the mortality rate in cases of amebic abscess of the liver has been due to two factors: (1) the administration of the specific drug emetine both preoperatively and postoperatively and (2) the appreciation that amebic abscess of the liver is sterile and that every precaution should be made to prevent its contamination with pyogenic microorganisms. Since it is frequently difficult to differentiate amebic hepatitis from abscess, emetine should always be used first unless there is an urgent indication for operation. Prior to Rogers' work amebic as well as pyogenic abscesses of the liver were treated by open drainage. After drainage the patient with amebic abscess did well for from one to three days, then toxemia developed and he became progressively worse and finally died. Rogers showed that this was due to secondary infection of a previously sterile amebic cavity. The combined mortality rate for patients treated by open drainage in a collected series was 43.8 per cent as contrasted with that of 6.4 per cent for those treated by closed drainage and emetine. If at the preliminary aspiration there is evidence of secondary infection, i. e. if microorganisms are present in the pus, open drainage is essential. Closed drainage consists of repeated aspiration of the abscess cavity by means of a large trocar and evacuation of the contents of the abscess. This is followed by injections of emetine. Emetine should be given in grain (0.064 Gm.) doses daily, not exceeding a total dose of 10 grains (0.648 Gm.) because of the danger of producing myocardial degeneration.

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## ECHINOCOCCUS CYSTS OF THE LIVER (HYDATID CYSTS)

**Etiology**—Echinococcus cysts of the liver are caused by the development of the larval or bladder stage of the tapeworm *Taenia echinococcus* the adult stage of which is found in the intestine of dogs and other canines.

Echinococcus cyst of the liver is rare in the United States but is common in regions of pasturage (Iceland Australia Argentina and elsewhere). In some localities there is a greater frequency in the male whereas in other regions the opposite is found. It is usually a disease of adults.

**Pathology**—The cyst is usually located in the right lobe sometimes attaining such size as to occupy the entire lobe. Not infrequently there are multiple cysts. The cyst wall is pearly opalescent elastic and laminated and has a granular inner lining. While the parasite is alive the content is a clear fluid but after the echinococcus dies the fluid becomes turbid and contains albumin. A fibrous capsule is formed around the cyst as a result of pressure and atrophy of the surrounding hepatic parenchyma. In this capsule are found numerous biliary canaliculi and vessels with some mononuclear and eosinophilic infiltration. Small daughter and granddaughter cysts also may be present in the chitinous membrane. Occasionally a hydatid cyst undergoes spontaneous death. Because of atrophy of the liver around the cyst there is usually observed resultant compensating hypertrophy of other parts of the liver.

**Symptomatology**—Clinical manifestation of the disease may never be present. Frequently there is a dragging sensation in the hepatic region and pain may be referred to the shoulder. Occasionally urticaria dyspepsia nausea and vomiting constipation jaundice and pseudo biliary colic may be

present. Local manifestations are more prominent than the constitutional ones. Depending on the location of the cyst the liver is enlarged upward or downward. A cyst near the dome of the liver may cause upward displacement of the diaphragm with signs of pleural effusion. When the cyst is anteriorly situated there is characteristic protrusion in the hypochondriac region. If it is inferiorly located a tense elastic tumor may be palpated. The characteristic hydatid thrill is inconstant but when present it is strongly suggestive.

**Diagnosis**—The condition should be suspected when there is cystic enlargement of the liver over a long period with few or no constitutional manifestations particularly in a patient who lives in a district devoted to pasturage. The hydatid thrill is confirmatory but not pathognomonic. The flood picture characteristically reveals a marked increase in eosinophils. Roentgen examination may be helpful. The complement fixation test is still technically difficult and although a positive result in competent hand is significant a negative result should not exclude the condition. The intradermal test of Casoni is important and helpful. Exploratory puncture should be performed with extreme caution and hesitancy.

**Complications**—Rupture of the cyst and suppuration are the gravest dangers. Perforation may occur into the stomach intestines or thoracic cavity. Rupture into the peritoneal cavity frequently results in severe or even fatal shock.

**Prognosis**—Spontaneous cure is occasional in young persons the prognosis is better. The total mortality has been estimated at 15 per cent (Deve). The outlook with operation is generally favorable.

**Treatment**—The treatment is strictly surgical. Some surgeons prefer the two stage whereas others use the one stage operation unless it is absolutely contraindicated. After the abdomen has been opened and the peritoneal cavity has been carefully protected with gauze packs the cyst is aspirated and 2 per cent formalin is injected. The cyst is then incised and the chitinous membrane removed. After the cavity has been wiped out with formalin immediate closure is advocated if no contraindications are present.

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## ACTINOMYCOSIS OF THE LIVER

Actinomycosis of the liver is extremely rare and is usually secondary. The primary focus is commonly in the alimentary canal, the infection spreading by direct extension or via the blood stream. The liver is usually enlarged and presents a characteristic honeycombed appearance owing to the coalescence of numerous small abscesses containing the typical bright yellow granular pus. Surface adhesions usually form but perforation may occur. The clinical manifestations are not characteristic. Pain and swelling in the right hypochondriac region, fever, chills, gastrointestinal disturbances, anemia and leukocytosis may be present. The prognosis is always grave and results of treatment are not encouraging. Incision and drainage of the abscess should be adequately performed. Iodides in large doses (up to 1000 grains daily) should be given as well as deep roentgen therapy.

## SYPHILIS OF THE LIVER

Syphilis of the liver is rarely of concern to the surgeon except in the tertiary stage and as a consideration in a differential diagnosis. In the tertiary stage of gumma formation the clinical manifestations may simulate portal cirrhosis, malignant neoplasm, hydatid cysts, abscess, cholelithiasis and actinomycosis. Differentiation is based on a positive Wassermann reaction, a history of syphilis, syphilitic manifestations elsewhere and obscure enlargement of the liver. In all doubtful cases a thorough course of mercurials and iodides should be tried.

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## TUBERCULOSIS OF THE LIVER

Tuberculosis of the liver is of little importance clinically and of less importance surgically, as it is usually only one manifestation of generalized tuberculosis.

## BENIGN TUMORS OF THE LIVER

Benign tumors of the liver are of more interest to the pathologist than to the surgeon. Lipoma, fibroma and myoma have been reported but are extremely rare. adenoma occurs infrequently. Cavernoma or cavernous hemangioma is the most frequent tumor of the liver. It generally occurs on the surface of the liver usually as a small bluish red tumor immediately beneath the capsule. Its presence is rarely recognized except at autopsy or during operation. Occasionally the tumor becomes very large and produces hepatic enlargement usually as the only clinical manifestation.

## PRIMARY CARCINOMA OF THE LIVER

Because of its rarity and its surgical unimportance, primary carcinoma of the liver warrants only a brief discussion. The incidence varies from 0.17 to 0.3 per cent of all necropsies and from 1.5 to 3 per cent of all cancers (Abel). It is most frequent in the fifth and sixth decades although there have been cases recorded in infants and children (Kilfox and Terry). There is a greater frequency of occurrence in males.

**Morbid Anatomy.**—Carcinoma may originate in the parenchymatous hepatic cells or the intrahepatic biliary duct cells. The former tumor is termed a hepatoma, the latter a cholangioma, a combination of the two is called a mixed tumor. Clinically there are three types of primary carcinoma of the liver. 1. Nodular or multiple primary carcinoma, the common form, is a highly malignant rapidly growing type characterized by multiple grayish bile-stained or hemorrhagic and necrotic nodules usually involving the entire organ. Histologically there is great variation in structure with a tendency toward reproduction of the more malignant features of carcinoma. 2. Primary massive carcinoma is characterized by a large single white or yellowish rather friable mass often occupying almost an entire lobe and not infrequently surrounded by small secondary growths. Considerable variation in structure may be observed microscopically with constantly present areas having a definite resemblance to normal hepatic cells. 3. The diffuse form is characterized by numerous small nodules and frequently infiltrates the

entire liver which is often small and contracted but sometimes slightly enlarged. The nodules are surrounded by connective tissue and grossly the picture so closely resembles that of hypertrophic cirrhosis that the malignant growth can be recognized only by microscopic examination. This latter characteristic has given rise to considerable discussion apropos of the possible etiologic relation of cirrhosis to cancer.

**Symptomatology**—As is characteristic of malignant disease elsewhere there is usually progressive loss of weight and strength with increasing secondary anemia. The onset is frequently insidious with gradually developing discomfort in the right hypochondrium, anorexia, emaciation, hepatic tumor, jaundice and ascites. Fever is frequently present especially when the tumor is of the rapidly growing type. The spleen is seldom enlarged. The disease usually runs a rapid course terminating within three to four months.

**Diagnosis**—Rapid and progressive enlargement of the liver, pain, loss of weight and strength, secondary anemia, jaundice and ascites are indicative of carcinoma of the liver. Roentgenographically the liver is fixed and enlarged disproportionately upward (Strong and Pitts). Primary disease elsewhere must always be suspected and differentiated as well as cirrhosis, syphilis, echinococcus cyst, abscess and gallstone in the common bile duct.

**Treatment**—Palliative therapy directed toward the alleviation of pain and discomfort is practically all that can be given. Resection of the growth is ideal if possible and if it can be definitely determined at operation that it is primary in the liver. Roentgen and radium treatment are of no practical benefit.

### PRIMARY SARCOMA OF THE LIVER

Primary sarcoma of the liver is very rare. Rolleston recognizes five types: (1) primary massive sarcoma characterized by a large tumor mass usually in the right lobe with frequent hemorrhage and cystic degeneration; (2) nodular or multiple primary sarcoma characterized by numerous nodules scattered throughout the hepatic substance; (3) diffuse or infiltrating primary sarcoma occurring most frequently in infants; (4)

primary sarcoma arising in a cirrhotic liver which is extremely rare; and (5) primary melanotic sarcoma the occurrence of which is questionable.

The clinical manifestations are excessive weakness which appears to be out of proportion to the general physical condition, hepatic pain, early anemia, definite enlargement of the liver, rapid emaciation and loss of weight. Jaundice and ascites are less common than in carcinoma. Death usually intervenes within three to four months. Treatment is palliative. Cases have been reported in which operative removal was followed by recovery but these are exceptional.

### SECONDARY CARCINOMA OF THE LIVER

Secondary carcinoma of the liver is frequent and occurs in about half of all patients with malignant disease. The primary growth is most frequently in the stomach, colon, esophagus, pancreas, gallbladder or uterus. There is a slightly greater frequency of occurrence in women and the average age is over forty. The liver is usually enlarged with a diffuse infiltration of metastatic nodules frequently near the surface. These nodules are rather hard except if enlarged when as a result of degeneration and necrotic changes they may become soft. This latter development is also the cause of the characteristic umbilication or central depression of the nodules. Secondary metastatic involvement may produce pain as a result of pericystitis or may cause ascites and jaundice as a result of pressure and engorgement.

### SECONDARY SARCOMA OF THE LIVER

Secondary sarcoma of the liver is less frequent than secondary carcinoma and is usually due to metastasis from a melanotic sarcoma of the uveal tract, rectum, skin, adrenal body, medullary tumor or bones. Only palliative therapy can be instituted in cases of metastatic tumors as they are invariably inoperable.

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# CHOLECYSTITIS, CHOLELITHIASIS, CHOLEDOCHOLITHIASIS AND AS- SOCIATED DISEASES OF THE LIVER

Improved conceptions with regard to the correlation of various functions of the body have led to a wider recognition of the disturbances that are directly attributable to or remotely associated with, disease of the biliary tract. A thorough knowledge of the anatomy, physiology and pathology of the biliary tract is the first requirement for skillful attention to the problems that arise from changes occurring in that system. Anything less than this will be inimical to the best interests of the patient.

Whether surgical treatment will be necessary will depend on the interpretation of the signs and symptoms. The principles and technique of operations for the correction of biliary disturbances have been established for a long time. Probably nowhere in the practice of surgery is judicious care so often associated with prompt recognition of anomalous anatomical relationships for in the biliary system such anomalous conditions are of comparatively frequent occurrence. An oversight or a mistake in carrying out the technical steps of the procedure may result in loss of life from hemorrhage or may lead to protracted invalidism as a result of calculous obstruction or injury to the common bile duct or hepatic ducts.

**Physiology.**—The liver is one of the major body depots of glycogen storage and consequently plays an important part in regulation of the quantity of sugar in the blood. Adequate store of glycogen aids markedly in the resistance of the liver to injurious effects of many toxins. Disturbance of the concentration of sugar in the blood rarely is encountered in pathologic hepatic or biliary conditions and when it is encountered it appears chiefly as hypoglycemia in chronic hepatic disease.

The liver likewise plays an important part in the metabolism of proteins including deamination of amino acids and formation of urea, destruction of uric acid, production and storage of body proteins, maintenance of serum proteins and formation of prothrombin necessary in coagulation of the blood. Furthermore, the liver is important in the metabolism and storage of fats. Detoxification is another important function of

the liver but concerning its exact mechanism little is known. The liver is responsible for the elaboration of bile salts and excretes them in the bile.

The liver has remarkable regenerative power. Mann and Fishback removed as much as 70 per cent of the total weight yet in a few weeks the remaining hepatic tissue had grown nearly to the normal total amount. Biliary obstruction and cirrhosis act to depress this regenerative power yet although hepatic functions are impaired selectively as shown by tests metabolism of carbohydrates and protein remains normal for some time.

There are many known facts which indicate that the gallbladder is of physiologic significance yet by no means of as great importance as the liver. The gallbladder stores and concentrates bile thus correlating the secretory activities of the liver with those of the

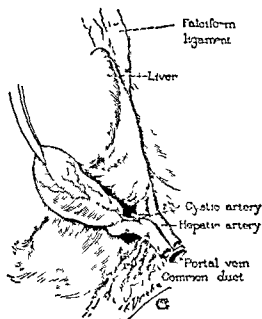


Fig. 393.—The gallbladder and extrahepatic biliary ducts showing a frequent anomaly of the blood vessels in which the right branch of the hepatic artery crosses in front of the common hepatic bile duct.

gastrointestinal tract. Loss of the gallbladder is compensated for by dilatation of the extrahepatic bile ducts. The relaxation of the sphincter and the emptying of the gallbladder have been shown to be closely associated with the ingestion of food. The gallbladder empties by contraction of its intrinsic musculature and this contraction and emptying are coincident with the production from the duodenal mucosa of a true hormone, cholecystokinin.

For measuring hepatic function many tests have been devised. The van den Bergh test is valuable for ascertaining the amount of serum bilirubin retained in the blood stream and also for distinguishing the obstructive and the hepatogenous jaundice in which the reaction is direct from the hemolytic type of jaundice which gives an indirect reaction. The dye retention test of Rowntree and Rosenthal, the mustard test of Delprat, the hippuric acid test, the galactose tolerance test and the determination of the quantity of

serum phosphatase plasma cholesterol and cholesterol esters and of total serum protein are tests of hepatic function which may be of value in the differential diagnosis of complicating hepatic disease or jaundice and in determining surgical risks and preoperative and postoperative therapy. When there is a prolonged prothrombin clotting time failure to respond to vitamin K denotes impairment of liver function. Medical and surgical treatment of disease of the biliary tract will advance with and in proportion to further improvements in investigative diagnostic methods.

On the basis of the van den Bergh reaction McVee made a clinical classification of jaundice: 1 Obstructive jaundice caused by occlusion of the biliary tract by calculus a structure or neoplasm. The van den Bergh reaction is always direct. 2 Intrahepatic toxic or infectious jaundice dependent on actual damage to parenchymal liver tissue. The van den Bergh reaction is usually direct but may be indirect or diphasic. 3 Hemolytic jaundice in which the reaction is truly indirect since the bilirubin never has passed through the hepatic cells to be reabsorbed by the blood and lymph as in the first two types. The test is of value because direct surgical treatment of the biliary lesion can be of value only in cases of obstructive jaundice.

In recent years additional information in regard to the physiologic processes of the biliary tract has been gained through visualization of the common and hepatic ducts under the fluoroscope and by roentgenographic methods after injection of a nonirritating opaque substance into these ducts.

**Pathology.**—Mann and Bollman have emphasized the point that biochemical methods will not accurately indicate the amount of temporary or permanent hepatic injury caused by biliary stasis and infection. Because of the close parallel to the hydronephrosis seen in the kidney following ureteral obstruction the term hydrohepatosis has been applied to the condition found in the liver following protracted complete obstruction of the bile ducts. The ends of the ducts become clubbed and varicosed. If infection is not present, the picture is that of hydrops of the entire biliary system. Microscopically the canaliculi are filled with biliary thrombi especially near the central hepatic veins; the hepatic parenchyma is atrophic and the finer bile ducts at the periphery of the so-called "hepatic lobules are numerous and tortuous. Eventually there is leukocytic infiltration along the ducts and the hepatic cells at the bases of the acini atrophy. A slow replacement by fibrous tissue then takes place. The ducts are at first filled with bile but as time goes on this is replaced by the colorless mucus derived from the epithelial cells of the ducts. These cells also remove the bile pigment causing the change in color. Eventually if the process is allowed to go on the stage of advanced cirrhosis is reached and the liver is markedly decreased in size. If however the presence of micro-organisms complicates the picture there is suppurative cholangitis with multiple hepatic abscesses around the terminal biliary ducts. The entire system of ducts is filled with bile-stained pus; the mucous membrane disappears leaving a sloughing submucosa and the walls and portal spaces are infiltrated with polymorphonuclear leukocytes. In the event the process becomes chronic, there is fibrosis of the walls

of the ducts and later the entire portal spaces and lymphocyes infiltrate the submucosa, particularly around the papillary saeculi. Therefore, it must be remembered that with long-standing obstructive jaundice there is diffuse organic injury which is the result of the lack of normal hepatic function. In these cases surgical procedures aim at establishing proper biliary drainage to enhance anatomic and physiologic regeneration in the liver as much as possible; a complete return to normal however cannot be expected. Some investigators state that 10 per cent of the normal amount of healthy hepatic tissue may be adequate to carry on a normal function.

The changes in the liver and bile ducts which are so frequently observed in association with disease of the gallbladder can scarcely be interpreted as merely incidental. The peculiar appearance of the surface of the liver immediately adjoining an infected gallbladder or in conjunction with disease of the common bile duct is well known. This condition is often loosely termed hepatitis. However there is no uniformity of opinion as to the exact nature of the part which the condition may play in the manifestations of disease elsewhere in the biliary tract. Although on the basis of the clinical history and the improved tests of hepatic function, it is possible to make a fairly accurate estimate of the degree of hepatic injury and the consequent disturbance of function there is still a great deal to be learned concerning the cause and true extent of the changes that have taken place in the underlying hepatic tissue in the condition known as hepatitis.

It is probable that chronic cholangitis forms the basis of most microscopically recognizable lesions of the liver associated with infection in the gallbladder with or without obstructive lesions of the common bile duct. However the condition appears in a large number of different forms and under a variety of circumstances. Cholangitis is an inflammatory process occurring in and around the walls of the intrahepatic and extrahepatic bile ducts varying from a simple scar of the lining epithelium to marked lymphocytic and polymorphonuclear leukocytic infiltration of the connective tissue of the entire portal spaces. Associated with this condition is proliferation of fibrous tissue that leads to tremendous thickening of the walls of the ducts. The description must be modified by the statement that although in most cases the changes are confined to the bile ducts proper such changes may extend to the intercellular biliary canaliculi and may there produce the condition known as biliary cirrhosis.

Although the usual conception of cholangitis is that it is the result of obstruction of the common bile duct with ascending lymphatic infection of the walls of the duct and portal spaces or that it is the result of ascending infection of the stagnant bile it should be recognized that cholangitis may occur as a hematogenous infection through the portal vein or hepatic artery or by direct extension from a diseased gallbladder through lymphatic structures to the liver. In the genesis of these conditions the element of infection is more significant than the presence of obstruction and although obstruction and retention of bile undoubtedly hasten and intensify the process once infection is established they do not by themselves produce cholangitis except after long periods. Cholangitis or

titis may be arbitrarily divided according to the degree of severity of the infection into the following classification: catarrhal, suppurative or gangrenous. However, a clear cut distinction such as is indicated by the classification is frequently impossible because of the fact that these pathologic stages are blended. The severity of an attack may be entirely without relationship to the pathologic picture presented by the gallbladder when it is examined grossly or microscopically. In the mildest forms there may be no visible change in the gallbladder beyond a little swelling of the mucosa that on microscopic examination reveals a lymphocytic and leukocytic infiltration of varying degrees. Later this extends throughout the walls which become edematous, soft and congested. The serosa exhibits a network of engorged vessels rapidly loses its smooth sheen, becomes dull and granular and readily adheres to surrounding structures. The mucous membrane is congested, is covered with sticky mucus and may exhibit here and there little ulcerations of the surface. Outpouring of a serous, fibrinous or bloody exudate alters the normal golden brown bile and renders the gallbladder tense and distended. If the process progresses further the contents are replaced by frank pus. Suppurative cholecystitis has occasionally been referred to as acute empyema, but the term empyema is more commonly used to describe the slow accumulations of pus in an old chronically infected gallbladder, a change associated with few symptoms. Finally, the mucous membrane becomes shaggy and necrotic and in places is shed entirely leaving granulating areas or dark red, greenish or blackened patches of gangrene penetrating to the serosal surface. Areas of impending perforation are more commonly found near the fundus and are associated with the pressure of stones or other factors interfering with the nutrition of the walls. In the most severe cases, particularly if the cystic artery is occluded, gangrene of the entire wall ensues and perforation almost certainly follows. The natural course of acute cholecystitis is subsidence without perforation leaving the gallbladder adherent to adjacent viscera or to the omentum but with chronic infection permanently established in the walls. Occasionally impaction of a stone

in the cystic duct is followed by absorption of the inflammatory product and hydrops of the vesicle. Acute catarrhal or suppurative cholecystitis may be followed by chronic empyema. Fistulas of all types may result from perforation into nearby viscera or rupture may take place into the liver with the formation of an abscess cavity containing stones.

The kind and severity of the symptoms exhibited by the patient depend to a great extent on the degree of pericholecystitis present and on the degree of inflammation present in the rest of the biliary tract and pancreas.

Localization of the process is almost the rule even following perforation. The incidence of general peritonitis is low. Abscess in the liver rarely occurs even in suppurative conditions of the gallbladder except when it actually perforates into the hepatic tissue. Pyelephlebitis with multiple abscesses is almost unknown. On the other hand, generalized non-suppurative infection of the liver or acute hepatitis is frequently seen. The liver is swollen and edematous and on microscopic examination reveals diffuse lymphocytic and polymorphonuclear leukocytic infiltration of the portal spaces. It is possible that the disease may be primary in the liver and secondary in the gallbladder. When the contents of the gallbladder are purulent or the organ has become gangrenous, it is unusual to find much infection in the pancreas. When this exists it may manifest itself as an apparently asymptomatic enlargement and hardening of the head of the gland in association with any degree of cholecystitis or it may occur as frank pancreatic necrosis. If pancreatitis is very marked or acute the patient will experience a much more severe pain which is usually in the same situation as the pain in most cases of cholecystitis; this pain may tend to localize deep in the epigastrium and to be projected through to the back. Fat necrosis about the pancreas may be found to a varying degree in these cases.

**Symptomatology.**—The symptoms in cases of acute cholecystitis are fairly well determined by the presence or absence of a stone obstructing the cystic duct. In the simple unobstructive type that frequently passes unrecognized as acute indigestion or



acute biliousness the onset is gradual and is ushered in by minor symptoms such as nausea loss of appetite a shivering attack and slight fever followed by indefinite aching pains in the epigastrium and right upper quadrant of the abdomen. Definite tenderness and rigidity of the right rectus muscle in the upper abdominal quadrant can be demonstrated and the pain slowly becomes more apparent but rarely requires morphine for relief. Occasionally it rises to the severity of colic if the inflammatory swelling of the mucosa is sufficient to occlude the cystic duct. With few exceptions such attacks subside under medical treatment.

Acute obstructive cholecystitis is characterized by a sudden attack of typical biliary colic which results from the passage of a stone down the cystic duct or its impaction in the neck of the gallbladder. Instead of passing off within a short time the colic changes to acute stabbing epigastric agony which is localized in the right subcostal region and is accentuated by the slightest movement of the diaphragm. Marked rigidity of the right rectus muscle and a slowly increasing area of tenderness over the gallbladder indicate the spread of pericholecystitis and involvement of the peritoneum in the inflammatory process. Vomiting and constipation are almost constant accompaniments. Chills may be severe but the temperature rarely rises above  $101^{\circ}$  to  $102^{\circ}$  F. The pulse is not diagnostic and the rate is usually proportional to the amount of fever present. Leukocytosis of moderate degree may accompany the condition although in more than 50 per cent of cases the leukocyte count will not be greater than 10,000. Jaundice in uncomplicated cases is not common and usually indicates involvement of the ducts when it does occur. This point is not generally appreciated but is of the greatest importance. A palpable mass in the right upper abdominal quadrant is present in about 70 per cent of cases. In a series of 508 cases studied by Judd and Phillips 484 patients had cholelithiasis and 43 had choledocholithiasis.

A conscientious perusal of the past history may be a great aid in establishing a diagnosis of acute cholecystic disease in a case in which there are definite pathologic changes in the upper portion of the abdomen. If

there has been a history of typhoid fever or repeated attacks of colic of the type associated with gallstones it is reasonable to assume that the gallbladder is very likely the seat of the trouble. However one must distinguish acute disease of the gallbladder from perforated peptic ulcer acute intestinal obstruction acute appendicitis pathologic changes in and adjacent to the right kidney acute infection in the right lobe of the liver and even coronary disease.

**Treatment**—In the treatment of acute cholecystic disease there are two very definite trends of thought. It is conceded that in many acute abdominal conditions it is safer to operate when the acute symptoms have abated rather than when the attack is at its height. Some very competent surgeons subscribe to this view in dealing with acute cholecystic disease.

There are so many variable factors involved in a consideration of acute cholecystitis that it often is difficult to tell not only the time of onset of the acute attack but also the duration of the acute phase. One of the most interesting features in the study of disease of the gallbladder is the inability frequently to correlate the pathologic findings with evidence obtained by careful clinical examination of the patient. It is well known that after the acute clinical signs in the right upper abdominal quadrant have subsided and when the pulse rate and temperature have returned to normal the gross and histologic picture may remain that of acute cholecystitis. If early operation is interpreted as operation performed within a few hours after the onset of the acute attack as nearly as the time of onset can be determined it will be noted that the tendency is more toward early surgical intervention. Two reasons have been advanced in support of early operation. (1) Operative procedure is facilitated if the operation takes place before marked evidences of pericholecystic and pericholeclochal inflammation have developed and (2) by early operation a possible diagnostic error whereby an acute inflammatory process in the appendix might be allowed to progress owing to the impression that the acute inflammatory process was in the gallbladder is obviated.

In a case of this type the surgeon frequently does not have the opportunity to

observe the patient until many hours or even days have elapsed after the onset of the disease. Under such circumstances the most satisfactory policy in most instances has been to allow the acute process to subside for three or four days with the patient under careful observation and during this time to pay particular attention to the patient's local and febrile reactions and to the degree of infection as suggested by repeated leukocyte counts, the Schilling count and the sedimentation rate of erythrocytes. The last named phenomenon has been found to be of great value because after all other signs and symptoms have disappeared an elevated sedimentation rate of erythrocytes may continue for some time to indicate persistence of the inflammatory process.

Operations for acute cholecystitis may be exceedingly difficult because of the existence of such complications as perforation of the gallbladder, the formation of an abscess or adhesions or the establishment of a fistula between adjacent viscera. When the duodenum becomes adherent to the gallbladder or the cystic duct and particularly when a cholecystoduodenal fistula results the operation may be extremely tedious. Difficulty is commonly encountered in separating and in closing the duodenum satisfactorily. In the event that an external duodenal fistula does form a rather serious postoperative complication is presented. If the fistula is small it may close spontaneously. A large one is usually so long in healing and so debilitating that operative intervention becomes advisable even though the risk is exceedingly great.

If acute cholecystitis is associated with biliary cirrhosis and jaundice the gallbladder is usually small and in some instances its function will be completely or almost completely destroyed. Ostensibly the inflammation in the viscus itself is then of secondary importance to that in the ducts and other hepatic tissues. The serious import of jaundice is well known. An effort should be made to decrease the jaundice before operating. The aim of the surgical procedure should be to reestablish the biliary intestinal continuity by the quickest and safest method. If stones are removed and drainage is established the gallbladder may be left for a subsequent operation although many

times the risk is no greater if cholecystectomy is performed at once and a secondary operation is avoided. Should there be diffuse inflammatory enlargement of the pancreas (pancreatitis) without obvious fat necrosis the best plan is to remove the gallbladder if this can be accomplished satisfactorily and establish drainage of the common bile duct by the use of a T tube. Many times it is difficult to determine whether the lesion in the pancreas is inflammatory or malignant. If there is any reason to suspect that there is a malignant condition in the head of the pancreas cholecystostomy should be performed or the gallbladder should be anastomosed to the stomach or duodenum. Although pancreatitis subsides more readily after removal of the gallbladder nevertheless biliary drainage will be efficacious if the lesion proves to be benign. Should it be malignant further palliative relief will be obtainable in some instances for the preservation of the gallbladder *in situ* will then permit the performance of a cholecystogastrostomy for diversion of the biliary secretions into the gastrointestinal tract. With associated fat necrosis the situation is serious but in many instances cholecystostomy and drainage of the pancreatic region have been helpful. In cases of extensive involvement of the pancreas any intervention should be confined to the relief of tension in the pancreatic tissues.

The consensus is that an acutely inflamed gallbladder should be removed if the procedure does not impose an unwarranted risk. One is confronted with an occasional case however in which institution of drainage seems advisable because the gallbladder is badly diseased and there is a great inflammatory reaction along the cystic and the common bile ducts or because the patient is a poor risk owing to age or illness. The decision to remove or to drain an acutely inflamed gallbladder rests on many factors in the individual case and an arbitrary rule of conduct cannot and should not be formulated.

#### CHRONIC CHOLECYSTITIS

Exactly what constitutes chronic cholecystic disease is in many instances a very debatable point. Obviously if calculi are present or if the wall of the gallbladder is grossly affected there can be little doubt re-

garding the process but there are many occasions when there is only a slight variation in the gross appearance of the gallbladder and when the clinical picture is certainly indicative of disease of the gallbladder out of all proportion to the appearance of the organ itself. Most of these cases will reveal some chronic change of tissue in the wall of the gallbladder detectable by careful microscopic examination. However these changes still may not appear adequate to explain the clinical syndrome and it is in these cases that cholecystectomy may give remarkably good or poor results without any clear explanation as to why the patient was or was not benefited by the procedure. In

many instances the characteristics of more than a single type may be observed. In a classification that seems to be of some practical significance the following are recognized: (1) chronic cholecystic disease due to infection (true chronic cholecystitis), (2) chronic metabolic cholecystic disease (cholesterosis of the gallbladder) and (3) clinical cholecystic disease without obvious pathologic change in the gallbladder.

Infection may reach the gallbladder in various manners: (1) Bacteria excreted by the liver may be carried in the bile to the gallbladder by means of the hepatic and cystic ducts; (2) infection may ascend from the duodenum by way of the common bile



Fig. 591.—Large smooth-walled gallbladder (lymphoma). The adjacent hepatic tissue is normal in appearance.

those cases in which the patient is relieved it is assumed that cholecystectomy effected some change in the rest of the biliary tract. In those cases in which the patient is not relieved it is probable that there is a low grade chronic infection throughout the entire biliary tree and liver which was not affected by removal of one small link in the chain. The gallbladder may be almost completely destroyed by disease and yet produce few if any symptoms. On the other hand a very slight change in the tissues of the gallbladder may be accompanied by very pronounced symptoms.

Three well defined types of chronic cholecystic disease are recognizable although in

duct; (3) infection may take place by direct extension of contiguous inflammatory processes from some adjacent organ such as the duodenum or colon; and (4) lymphatic structures and the blood stream may act as conveyors of the bacteria. For a long time it was thought that infection originated from organisms in the bile. It is now almost universally believed that infection is usually hematogenous. The work of Rowen suggests that certain organisms chiefly streptococci have a selective affinity for the gallbladder and that they may come from any chronic focus of infection in the teeth, tonsils or prostate gland. In this connection it is well to remember that when once the gall



Fig. 59.—Thick walled fibrous gallbladder with evidence of a lesion to abdominal viscera (extensive chronic cholecystitis). The liver appears normal.



Fig. 59b.—Marked degree of hepatitis of the right lobe. The gallbladder is small.

bladder is infected it in turn may become a focus. Thus removal of an infected gall bladder may be followed by subsidence of symptoms of arthritis and neuritis. How

ever it is often impossible to recover organisms from the gallbladder in which there is definite histologic evidence of infection. Positive cultures are more often obtained



Fig 397—Large gallbladder with markedly thickened fibrous wall (chronic empyema) There is some associated hepatitis



Fig 398—Extensive inflammatory disease of the gallbladder causing adhesion to the abdominal wall The liver is small and atrophic

from the wall of the gallbladder than from the stones or bile therein. The bile gives positive results in about 7 per cent, stones in 10 per cent and the wall of the gallblad-

der in 40 per cent of cases. A. L. Wilkie obtained positive cultures from the gallbladder in 86 per cent of a series of cases of chronic cholecystitis. The invading organ

ism in most instances is the streptococcus but the colon bacillus typhoid bacillus Welch's bacillus and others have been found. In fact it is probable that in most cases not only the wall of the gallbladder is involved but also the liver the bile ducts and frequently the pancreas.

The pathologic picture of chronic infectious cholecystic disease varies within wide limits depending on the duration and virulence of the infection the presence or absence of stones and whether or not the cystic duct remains patent (Figs 594 to 598). In most instances it is probable that the infectious process is more or less chronic and of low grade from the onset. In some cases the sequelae of acute inflammation will be present. Acute exacerbations of infection occur in chronically infected gallbladders especially if the cystic duct becomes obstructed. The first noticeable change is thickening of the wall of the gallbladder and an abundance of fibrous tissue displacement. The mucosa may be hypertrophic atrophic ulcerated or completely destroyed. There may be extensive infiltration of the remaining coats of the wall with round cells and an abundance of fibrous tissue. The serosa loses its glossy appearance and frequently becomes adherent to surrounding structures. The lymph nodes along the cystic and common bile ducts are usually enlarged. In many instances gall-stones are found within the lumen of the gallbladder. Although it is probable that infection is the most constant primary factor in the production of gall-stones there are undoubtedly cases in which stones precede infection and the etiology of the cholelithiasis must be explained on the basis of an altered metabolism. If the cystic duct becomes obstructed because of infection or because of impaction of a stone hydrops of the gallbladder often results and the viscus may reach an enormous size. In such instances the content is usually a clear colorless mucus but empyema is not an uncommon occurrence. Perforation is more common in a gallbladder that is involved in an acute infectious process than in one in which the infection is of the chronic type. However when perforation does occur with the latter it is usually into an adherent omentum or some viscus such as the duodenum colon liver or stomach.

Chronic metabolic disturbances are the basis of another type of cholecystic disease. Frequently signs of inflammation are absent from a gallbladder that contains stones of pure cholesterol although the patient presents all the characteristic symptoms of cholecystic disease. A causative factor in the formation of the stones apparently is disturbance in the metabolism of cholesterol the exact nature of which is not completely understood although cholestasis of the gallbladder seems to play a part. In many reviews are reported clinical cures following removal of gallbladders of the strawberry type without stones. This would seem to indicate that removal of this one link from the chain of disturbed metabolism of cholesterol stops the process and allows a return to normal.

To admit that clinical cholecystic disease exists without obvious pathologic change in the gallbladder probably is a confession of lack of knowledge concerning the underlying disturbed physiologic processes of the biliary tract. There is an occasional case however that presents just such a problem. If the gallbladder is not removed symptoms will continue if cholecystectomy is performed the symptoms often will be relieved. Frequently there are a few small areas of cellular infiltration to support the diagnosis but this does not settle the question. Further investigation no doubt will throw light on this group of cases and may show that the primary trouble is hepatitis and cholangitis in which the gallbladder is playing only a part. At present the decision for or against removal of the gallbladder must depend on a careful scrutiny of the clinical history. Thus from a practical standpoint in cases of this type the clinical history is of greater importance than the roentgenologic data or the gross pathologic picture at the time of opening the abdomen. Present surgical procedures must be based on these practical considerations.

**Symptomatology.**—The symptoms of chronic cholecystic disease may vary within wide limits depending on the severity of the condition and the sensitivity of the individual patient. Many gall-stones apparently do not produce symptoms as they are often discovered during the general examination of patients who consider themselves per-

fectly well and they are found frequently at necropsy of subjects who had no complaints referable to the biliary tract. At the other extreme are patients with most severe biliary colic who are found at operation to have a minimum of pathologic change in the gallbladder.

The most characteristic symptom of chronic cholecystic disease is recurrence of attacks of biliary colic. This symptom when typical is pathognomonic of disease of the biliary tract. The pain characteristic ally begins more or less suddenly in the epigastrium or right upper quadrant of the abdomen and is projected around the right costal border to the right subscapular region. It is most severe and often requires repeated injections of morphine for relief. At the onset the patient frequently is nauseated and vomits. There is a picture of extreme distress which without a doubt establishes the fact that there is intense pain. The pain may cease as suddenly as it began after a few minutes or hours but the usual sequel is marked residual soreness in the region of the gallbladder for several days. The colic may or may not be recurrent and during the interval there may be entire freedom from all symptoms. The temperature usually remains normal or subnormal during the *paroxysm* and the pulse is accelerated. Most patients with chronic disease of the gallbladder will have at least one attack of biliary colic during the course of the disease. Many patients characterize their distress as a dull aching soreness under the right costal border which is made worse by jolting or jarring or by eating a full meal. In some cases the sensation is merely a feeling of fullness.

Digestive disturbances of one sort or another are present in most cases of chronic disease of the gallbladder. Epigastric fullness after meals with bloating and gaseous eructations is extremely common and may be the most troublesome feature of the disease. Certain patients will not tolerate fried or greasy foods and others coarse vegetables but many find that mere overloading of the stomach with any type of food seems to cause distress and may precipitate an attack of colic.

Jaundice is not a common accompaniment of chronic cholecystic disease if the

gallbladder alone is infected. However a large stone in the neck of the gallbladder may occlude the common bile duct by pressure. There may also be transient jaundice which is the result of associated hepatitis or cholangitis; this jaundice leaves as the attacks subside.

There may be little besides the information contained in the history on which to make a diagnosis of chronic cholecystic disease if the patient is seen sometime after the colic has subsided. As a rule however on careful palpation in the right upper quadrant of the abdomen there will be some tenderness to pressure as the margin of the liver moves down on deep inspiration. Occasionally if the gallbladder is extremely large owing to chronic obstruction of the cystic duct it can be felt as a rounded mass moving up and down freely with the liver during respirations. If the patient is seen during or immediately following an attack of colic there will be marked tenderness in the region of the gallbladder with rigidity of the overlying abdominal muscles.

A carefully taken clinical history is most important in the diagnosis of chronic disease of the gallbladder. If one or more of the foregoing symptoms have been elicited suspicion should be aroused. In the event one is not able to make a definite diagnosis the decision as to whether or not the condition requires surgical intervention is the paramount issue.

*Cholecystography* may prove an invaluable aid to a just decision if due consideration is given to the other available data including the history. Cholecystography is primarily a method of depicting a test of the concentrating ability of the gallbladder. The interpretation rests on the determination of the amount of variation from the normal density of the cystic shadow. Positive data regarding the degree of remaining function in the gallbladder are reliable in as high as 97 per cent of the cases; however with normally functioning gallbladders the chance of error is about 10 per cent. It is important to stress the point that cholecystography should not be relied on without clinical data to affirm or deny the presence of disease of the gallbladder. Cholecystographic findings may be of assistance in cases in which for one reason or another diagnosis has been

obscured but all the evidence should be weighed concurrently in making the final decision. Of course when gallstones are visualized the diagnosis is made but the possibility of their presence in spite of negative cholecystographic findings makes it imperative never to lose sight of the fact that the essential point in the diagnosis may be a typical history alone.

**Treatment**—According to the present conception of chronic cholecystic disease some change in the wall of the gallbladder represents the seat of the trouble. The only way in which to eradicate the primary factor is to remove the organ. There are numerous records indicating that cholecystostomy has given permanent relief and occasionally in chronic cholecystic disease it may be indicated with the idea that it will later be followed by cholecystectomy but when all things are considered cholecystectomy is much more satisfactory. Furthermore chronic cholecystic disease in almost all cases is essentially a surgical problem and most certainly so if stones are present. The risk of operation early in the course of the disease is low and the disastrous sequelae of obstructive jaundice and extensive hepatitis justify vindicate the opinion that early surgical intervention is safest and wisest.

Usually the presence of stones in the gallbladder is sufficient to justify surgical exploration even if the patient does not complain of symptoms referable to the gallbladder. It is obvious that factors in the individual case will influence the surgeon's conduct in this matter. Frequently, varying degrees of inflammatory change may be observed in the liver and the pancreas in association with "symptomless gallstones." To remove the gallbladder in such a case may tend to protect the patient against the progression of the related disease and against the possibility of subsequent mechanical obstruction of the cystic or the common bile duct by a calculus.

The removal of the gallbladder is contra-indicated in certain cases and drainage is substituted. The condition under which cholecystostomy is preferable may be summarized as follows: (1) in the presence of local technical difficulties such as obesity which make it impossible to identify important structures; (2) if the general condi-

tion of the patient is such that cholecystectomy would be hazardous (3) in some acute conditions of the gallbladder and liver; (4) in the presence of obstructive lesions of the common bile duct when relief from jaundice is the paramount issue and (5) when the character of obstruction of the common bile duct is such that cholecystogastrostomy may need to be performed later.

Cholecystostomy which is carried out because of inflammatory disease offers some chance of cure in itself. In one study it was found that approximately a fourth of the patients who had undergone cholecystostomy had persisting severe symptoms (about 50 per cent of these later submitted to cholecystectomy); a fourth had some mild symptoms and the remaining half had no distress referable to the biliary tract.

Occasionally cholecystostomy is performed although the procedure is usually far from satisfactory and has a very limited field in surgery. The inadvisability of removing stones and leaving the gallbladder is evident when one considers the probability that the infection is in the wall of the gallbladder. Furthermore suturing the gallbladder without draining it is a more hazardous and certainly a less efficacious procedure for prolonged drainage might at least be some aid in clearing up the inflammatory process. The thesis therefore that if the gallbladder can be saved it will resume its normal function is not well founded and certainly clinical experience indicates that in most cases cholecystectomy is the procedure of choice.

### CHOLEDOCHOLITHIASIS

The symptoms arising from stones in the common bile or hepatic ducts are the indicative of cholecystic disease plus the added factor of jaundice. It is of course possible to have stones in the ducts without ensuing jaundice and if symptoms persist following a typical attack of acute biliary colic disturbance in the ducts should be suspected. The presence of jaundice depends on whether the calculus passes through the ampulla into the duodenum or becomes firmly impacted in the ampulla and acts as a ball valve at the lower end of the bile duct at times becoming dislodged and floating about in the bile stream. If obstruction is com-



plete the serum bilirubin will become fixed at from 20 to 30 mg per hundred cubic centimeter of blood. Usually if impaction is not constant the jaundice fluctuates for at times it is possible to have an ample flow of bile. Fluctuating jaundice and the presence of pain are the outstanding features that help to distinguish between obstruction due to a calculus and that due to a neoplasm although it should be remembered that pain is sometimes an early and persistent accompaniment of neoplastic growth. There are many cases in which the cause of jaundice cannot be determined until an exploratory operation is performed. In either case if obstruction is of long duration the injury to the liver will be great and not infrequently the condition will be terminated by an acute suppurative cholangitis.

The selection of the optimal time for operation in the presence of a marked degree of hepatic injury is of paramount importance for it is a factor in reducing the surgical mortality. Patients with obstruction of the biliary passages of considerable duration do not stand operative procedures well. Those with deep jaundice of short duration are better risks than those whose jaundice is less marked but has been of longer duration. An operation should not be undertaken when jaundice is fluctuating nor at a time when hemorrhagic tendencies are increasing. If fever is present it is wise to wait a reasonable time for the acute infection to subside. Dehydration and poor nutritional states can be relieved to an appreciable degree by restorative measures. When death occurs in these cases it is usually from hepatic and renal insufficiency.

Fortunately stones in the intrahepatic ducts are not common. However this possibility should be kept in mind considering the recurrence of stones after operation on the gallbladder and ducts. Calculi in the substance of the liver are rare. Intrahepatic stones may not be manifested by symptoms for years but occasionally the outcome of such a condition is the development of a serious suppurative cholangitis.

The history of jaundice or its presence should make examination of the common bile duct imperative. If much dilatation of the duct is found it should be opened and explored with a probe and a scoop but it

should be remembered that in the presence of a non functioning gallbladder the duct will be dilated. Removal of the gallbladder should be deferred until the lumen of the duct is proved to be sufficient for the viscus may be utilized advantageously for an anastomosis to the intestine to divert the flow of bile. With deep jaundice present it may be safer to institute drainage of the gallbladder than to perform cholecystectomy. Supraduodenal choledochotomy is the best means of removing calculi from the common bile and hepatic ducts.

*Preoperative and Postoperative Treatment*—The patient should be observed in the hospital for several days before operation. The three chief surgical complications to be kept in mind are hemorrhage, hepatic insufficiency and renal insufficiency.

The best method of protecting the patient against hemorrhage during and after operation is by administration of vitamin K. It has been well demonstrated that in patients who have obstructive jaundice from any cause, biliary fistula or mild hepatic damage there may develop a tendency to hemorrhage. In most instances this tendency can be corrected by the proper administration intramuscularly, intravenously or by mouth of vitamin K in the form of synthetic compounds. It is a wise precaution to give vitamin K for one or two days prior to any type of operation performed on the biliary tract regardless of whether or not the patient is jaundiced. Of the synthetic compounds 1 to 2 mg daily for one two or three days administered by mouth together with 10 to 15 grains of animal bile salts seems to be an adequate dosage or 1 to 2 mg administered by the intramuscular or the intravenous route without bile salts is sufficient. At times it may be necessary to administer vitamin K at the operating table especially in cases of jaundice or hepatic injury if hemorrhagic oozing begins. The patient should receive vitamin K after surgical operation for at least four or five days and the prothrombin clotting time should be followed carefully for at least another five days. Any rise in the prothrombin clotting time calls for further administration of vitamin K.

Occasionally patients who from one cause or another have severe hepatic parenchymal

damage must be subjected to surgical operation. Frequently the prothrombin clotting time is elevated and will not respond to the administration of vitamin K. In our experience and in the experience of many others this phenomenon often indicates that the liver is damaged rather badly. In spite of failure of response in the prothrombin clotting time the patient should receive the same type of preoperative and postoperative treatment with vitamin K as if response had occurred and if hemorrhage takes place transfusions can be employed. After surgical operation in a case in which response to the administration of vitamin K has failed to take place the surgeon should observe the patient carefully for symptoms of impending hepatic coma which some times results in cases of this type.

Calcium chloride also has been used in attempts to increase coagulability of the blood but just what part it plays in this respect is not clearly understood. Since an injured liver can utilize carbohydrates more readily than other nutrient substances large quantities of a 10 per cent solution of glucose are administered intravenously either alone or combined with a 1 per cent saline or a 2 per cent solution of sodium lactate. The role of sodium lactate is not definitely known but in some instances it seems to aid in restoring hepatic function. These measures are further supplemented by prescribing a diet high in carbohydrates. The increased intake of fluid just described serves a double purpose in the presence of jaundice for it is also excellent treatment for a coexisting toxic nephrosis.

Postoperatively carbohydrates are given in abundance and intravenous glucose solutions are continued as before operation. The administration of oxygen by the tent method or by nasal catheter is frequently of value if there is any evidence of a pulmonary complication.

### CHOLECYSTOSTOMY

The essential requirement of an incision for operation on the gallbladder or bile ducts is that it must be properly placed. When this is accomplished the incision facilitates the necessary exploratory procedures and reduces the liability of ensuing hernia. The best exposure is obtained by making the incision from the right side of the ensiform

notch obliquely downward to a point 4 cm to the right of the umbilicus. The anterior sheath of the rectus muscle is divided in the same line as the skin and the right rectus muscle is retracted laterally after being freed from its sheath on the mesial side. The posterior sheath of the rectus muscle and peritoneum are then opened about 1 or 2 cm from the median line. Better exposure of the biliary tract is obtained by incising the peritoneum as high as possible toward the thorax rather than by extending the incision downward. Clamping and cutting the suspensory ligament of the liver is often ad-

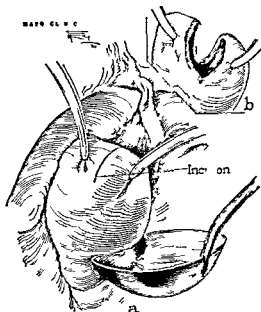


Fig 599—*a* Gallbladder grasped with two forceps. A large scoop is pressed against the external surface as an aid in emptying the vesicle and catching its contents. *b* Incisions made in the gallbladder.

vantageous in bringing the biliary tract into view.

The technique of performing cholecystostomy varies somewhat according to whether the organ is markedly distended with bile but is free from inflammatory changes or whether it is thick walled and contracted and contains stones. In the former case the patient is usually deeply jaundiced and the obstructive lesion lies in the head of the pancreas. Here the main object of the operation is to relieve the jaundice with as little risk of hemorrhage as possible. It may be the only operation considered necessary or it may be preliminary to the cholecystogastrostomy. If the gallbladder is thick

walled and contracted and contains stones, the operative field is packed off and the fundus of the gallbladder is held in the grip of two curved clamps and elevated well up into the field. The content of the organ is aspirated by means of a trocar. The fundus is then opened with scissors, and curved forceps are re-applied to the edges about the opening. The contents of the gallbladder are then removed with a scoop. A large scoop is pressed against the external surface of the viscus, at the level of its neck, to catch any overflow of bile or stones (Fig 599). When

The wound is closed without fastening the fundus to the peritoneum. A split tube is placed outside the gallbladder (Fig. 601).

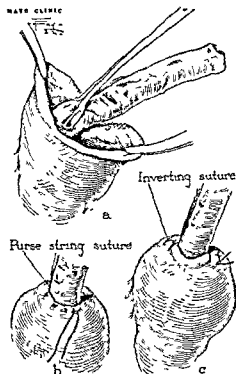


Fig 600—*a*, A dressed tube is placed in the gallbladder; *b*, purse string sutures are placed about the tube, *c*, a second row of inverting sutures is employed

the gallbladder has been entirely emptied, a dressed rubber tube, consisting of a central core of heavy rubber tubing with a bore of 1 cm wrapped in gauze and surrounded by a Penrose drain, is placed in the gallbladder so that it projects almost to its neck. A rubber catheter may be substituted for the dressed tube, although this usually is not as satisfactory. The fundus is then closed with a purse string suture (Fig. 600), and the dressed tube is tightly anchored to the wall of the gallbladder by passing the suture through it at one point. Usually a second purse string suture is placed above the first.

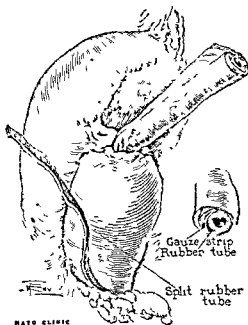


Fig 601—Operation completed The split tube is placed beside the gallbladder

### CHOLECYSTECTOMY

Removal of the gallbladder is the procedure most frequently indicated in the presence of: (1) subacute or chronic cholecystitis with or without stones, (2) chronic empyema, distention or hydrops of the gallbladder due to blockage of the cystic duct by a calculus, stricture, neoplasm or external inflammatory deposit, (3) gangrene of the viscus itself, (4) pancreatitis in association with disease of the gallbladder if only slight jaundice is present, (5) calcareous degeneration of the gallbladder, (6) cholelithiasis of the gallbladder, (7) primary benign or malignant tumor confined to the gallbladder and (8) clinical cholecystitis, that is, until the true nature of the disturbed physiologic process in this last condition is better understood. Of course if there is an obstructive lesion in the common bile duct and its satisfactory removal is problematic, the gallbladder should be left in situ, if possible, as it will often prove useful in restoring biliary-intestinal continuity. Cholecystectomy will accomplish a great deal toward the relief of the pancreatitis which is so often found in association with disease of the gallbladder, but in many in-

stances prolonged drainage of the common bile duct should also be maintained

Although there is not a direct relationship between cholecystic disease and coronary disease in certain types of cases however those in which colics recur those in which cholecystic disease has impaired digestion so that the general condition has suffered and those in which flatulence has existed or in which the patients have been very ill either from jaundice or from toxic states removal of the gallbladder has resulted in improvement in the general con-

dition and consequently in direct betterment of the cardiac condition

gallbladder and thereby be mistaken for the cystic duct. In about 7 per cent of cases there is some variation from normal in the arrangement of the biliary ducts the hepatic artery or the cystic artery. It is therefore highly important to identify the cystic duct and artery positively before they are ligated or cut. If the situation of these structures has been ascertained there is no objection to ligating them together. Part of the success of the operation depends on the proper placing of moist gauze packs for the exclusion of other intra abdominal organs from



Fig. 609.—The common and cystic bile ducts visualized. The cystic duct is clamped with the forceps.

dition and consequently in direct betterment of the cardiac condition

The incision is made in the same way as for cholecystostomy. Adhesions should be separated carefully before proceeding further every effort being made not to injure large blood vessels which may retract into fatty tissues and later produce hematoma. Before anything more is done the common bile duct should be identified and exposed. Usually injury to this duct results from efforts to control bleeding from the cystic artery. It may also result from clamping the cystic duct too near the common bile duct or the common bile duct may be strangulated from too much tension on the

the operative site. Frank hemorrhage from the cystic artery and injury to the common bile duct are the two great dangers in performing cholecystectomy. Cholecystectomy will not only be easier but safer if it is begun at the cystic duct since the circulation will be controlled at the outset.

With the left hand the assistant exposes the operative field mesially another assistant rotates the liver into the wound and holds it there by making traction on the suspensory ligament and lateral traction on the right edge of the wound. Dissection of the cystic duct is then commenced. When the body of the gallbladder overlies and is adherent to the common bile duct it must be

separated with great care. The peritoneum is then incised and by means of blunt dissection the cystic duct is cleared and isolated from the fat that surrounds it. A curved forceps is passed from below so that the beak projects between the duct and the cystic artery. After 2 cm. of the cystic duct have been exposed by separating the blades the duct is caught by two narrow bladed 7 inch clamps and divided either by knife or

clamp which has been used to close the cut end of the duct. An edge of peritoneum is left on each side of the fossa of the gall bladder to facilitate subsequent suture. Before the gall bladder is entirely removed from the liver the stump of the cystic duct is doubly ligated with no. 1 chromic catgut and the cystic artery is securely tied with the same material (Fig. 604). The gall bladder is then quickly removed in closure

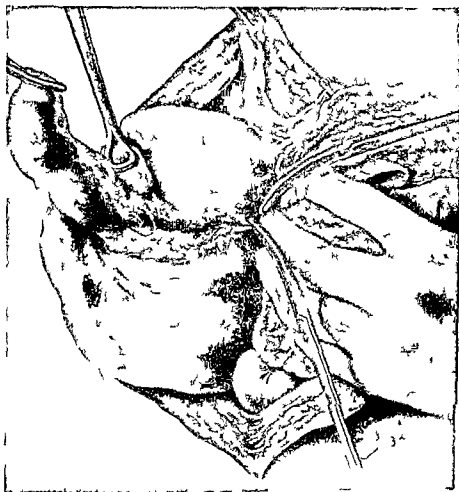


Fig. 603—The cystic duct is clamped and the gallbladder being dissected from the cystic duct upward. The cystic artery is clamped.

scissors (Fig. 605). The two ends are immediately touched with a solution of iodine. The lower clamp should be at least 2 cm. from the common bile duct so that sufficient room is left to apply the ligature. Next the cystic artery is separated in the same manner and divided. If another branch should be present it is treated similarly. The gall bladder is then pulled from the liver in the plane of cleavage (Fig. 603) which is easily demonstrated by maintaining tension on the

of the region is made by a continuous suture (Fig. 605) commencing at the point at which dissection of the gallbladder was begun. Care should be taken not to include or strangulate any hepatic tissue in this suture. The suture is carried to the inferior margin of the liver where it is tied and cut. Closure of the wound without drainage is a perfectly safe procedure if the surgeon is certain that the cystic duct and artery have been securely tied if the fossa of the gallbladder



Fig 604.—The cystic duct is doubly ligated, and the cystic artery is caught in a stitch suture.

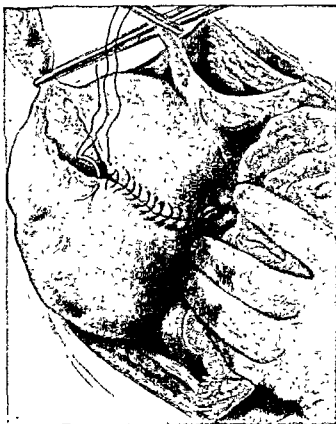


Fig 605.—Suture used to peritonize the cholecystic fossa.

has been carefully sutured and if the operative field is dry Drainage is imperative in cases in which there is active infection or leakage of bile The presence of half of a rubber tube drain does not add to the risk of development of hernia provided the tube is brought out high up in the wound under these circumstances it does insure a safer convalescence

### CHOLEDOCHOSTOMY

The experienced surgeon is justified in performing choledochostomy if there is a history or evidence of obstruction of the common bile duct and even in the absence of symptoms if the duct is found to be enlarged Obstruction that is the result of a malignant growth is a separate problem Usually a growth of sufficient size to cause obstruction to the flow of bile through the common bile duct can be diagnosed as such by palpation The gallbladder should never be removed until the necessary treatment of the common and hepatic ducts has been effectively carried out (Figs 606 and 607)

After exposure of the common bile duct the anterior wall is elevated by grasping it with two Allis forceps about 0.5 cm apart and a longitudinal incision is made between the two instruments If the duct is sufficiently dilated the incision should be large enough to admit the examining finger However if a stone can be palpated in the common bile duct before it is opened the incision can be made directly over the stone by grasping the duct and fixing the calculus between the thumb and finger of the left hand Then after removal of the calculus other loose debris can be sponged scooped or washed out of the duct The adjacent structures should be manipulated no more than is absolutely necessary in order to preclude injury to the portal vein or the hepatic artery

When the common bile duct is explored for any reason immediate closure of the opening is usually not advisable for in most instances in which choledochostomy is indicated cholangitis is present which is best treated by free drainage of the biliary tract The extent of the disease is the important factor in judging the length of time drainage should be maintained A Kehr-Dwyer T tube is preferable for this purpose but

should there be only a mild degree of cholangitis cirrhosis or pancreatitis the use of an ordinary catheter in the duct may suffice However the advantages gained by using a T tube are (1) The tube will remain in place as long as it is required and can be removed with ease (2) the flow of bile can be controlled by clamping the tube (3) irrigation of the ducts can be instituted and (4) fluids can be introduced into the duodenum for feeding purposes when required As far as can be determined there has not been a tendency toward stricture of the common bile duct as a result of pro-

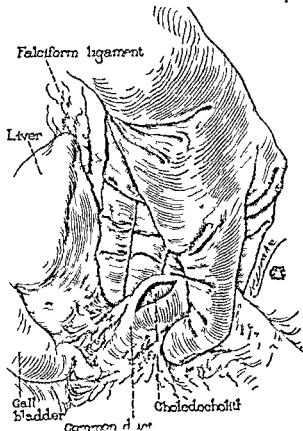


Fig 606—A palpable stone in the common bile duct is being grasped between the fingers The incision was made directly over the stone

longed contact with a rubber drainage tube The ordinary catheter will fall out of its own accord in about nine or ten days but steady traction must be applied on a T tube before it can be removed In either instance the resulting biliary fistula is prompt in healing

As has been shown frequently much information in regard to the patency of the common bile duct can be obtained by injecting radiopaque oil through the T tube and following its course by means of the

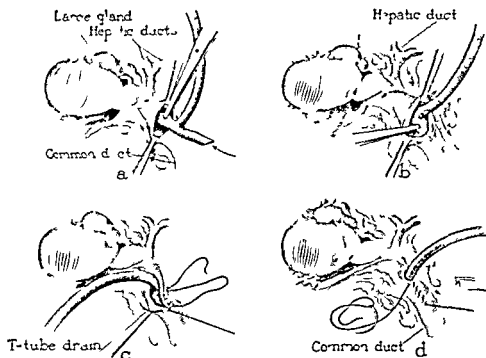
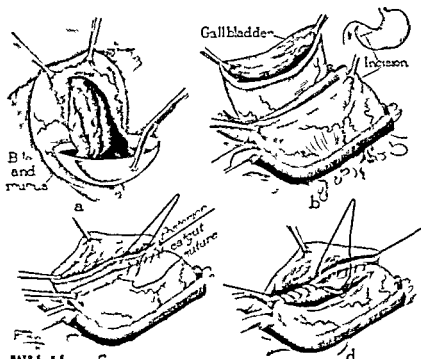


Fig. 60—*a* The incision in the common bile duct is held open by Allis forceps and the proximal end of the T tube is inserted *b* the distal end of the T tube is placed in the common duct *c* the opening in the common duct is closed by continuous suture over the arms of the T tube *d* the common duct is closed snugly about the T tube which emerges from the upper end of the incision in the duct





regulating mechanism of the biliary tract may account for some of the symptoms that occur or persist after cholecystectomy for it has been shown experimentally that under certain conditions there is an increase in the pressure in the common duct after the removal of the gallbladder. A gallbladder which has undergone pathologic change may still be able partially to regulate the intraductal pressure but if this function of the viscus is completely lost as a result of rather gradual progress of the process finally terminating in extensive disease there will be compensatory dilatation of the common bile duct. When a normally functioning or partially functioning gallbladder with or without stones is removed an imbalance in pressure is produced immediately. This may explain why some patients continue to have colic for a short time after cholecystectomy. Disturbances of this type will persist only until the tension becomes sufficient to produce dilatation and finally overpower the sphincter. Evidently in some instances the sphincter is not easily dilated and has a tendency to be spastic. This situation is particularly frequent among high strung persons who are also likely to have an irritable bowel.

Colic following cholecystectomy not due to stone always presents a difficult problem. The attacks of colic are usually the result of persisting infection in the tissues and they decrease in severity as the infection subsides. Before any secondary surgical procedure is performed sufficient time should be allowed to elapse to make certain that the symptoms will not cease spontaneously. Meanwhile such conservative measures as a regulated diet and duodenal drainage often prove efficacious. Magnesium sulfate may be introduced through the duodenal tube for the purpose of lowering the sphincteric tonus. Occasionally the colic is wholly the result of dietary indiscretions. Parietal neuralgia, renal and gastric colic or angina pectoris may be responsible for symptoms that seem to be referable to the biliary tract and so the difficulty of making a clear-cut preoperative clinical diagnosis is increased. The possibility of the existence of an ulcer in the duodenum should always be carefully considered. A clinical diagnosis of stone in the common duct is likely to be made erroneously. Jaundice or persistent severe in-

termittent colicky pain should be included in the indications for the second operation or many patients with functional disturbances will be subjected to abdominal operations that are predestined to be fruitless.

If an exploratory operation is carried out and the presence of a stone is not demonstrated it becomes necessary to search elsewhere for the cause of the disturbance and to determine whether there is any change in the pancreas, liver or ducts. Occasionally an ulcer on the posterior wall of the duodenum will give symptoms which are indistinguishable from those of disease in the biliary tract although roentgenologic investigation of the stomach and duodenum has not revealed the presence of a lesion. The frequency with which secondary operation is required for colic following cholecystectomy may be estimated from the fact that in a five year period during which cholecystectomy was performed 4291 times there were only 39 patients with symptoms of such severity that secondary exploration of the ducts was justifiable because of colic that was not due to a stone.

Prolonged drainage of the biliary tract by the use of a T tube is the procedure of choice in the event surgical intervention is required because of colic following cholecystectomy. Ordinarily the tube should be allowed to remain in place for from three months to a year depending on the extent of the disease. Sometimes emergencies arise which make it difficult to keep the tube *in situ* for a period deemed adequate for relief. It is unreasonable to expect free drainage of the biliary tract for a few days or two or three weeks to relieve a condition that has been developing for several years. Sometimes because of underlying pathologic changes that have created irreparable injury it is impossible to improve conditions by any known means.

Before removing the tube from the duct it is advantageous to make a study of the biliary tree. This can be done by injecting radiopaque oil through the tube. The patient is placed under the fluoroscope so that the passage of the medium through the biliary tract can be observed. This makes it possible to obtain a better understanding of the biliary tract especially as to the patency of the ducts.

The T drain is removed by gentle traction on the long arm of the tube. In most instances anesthesia will not be required for this procedure although occasionally it will be advisable to give a few whiffs of gas to the patient who is nervous or high strung. If the ducts are patent there will usually be no external drainage after removal of the tube; the opening in the duct usually heals quite promptly. Not infrequently patients living at a distance are able to return home twenty-four hours later.

On a few occasions paravertebral injection of novocain has been used for the relief of severe recurring colic. This was done on the basis that in the experimental animal dilatation of the cystic duct is accompanied by marked inhibition of respiration, vomiting, struggling and other evidences of pain and that these responses were abolished by section of the right splanchnic nerve. This procedure or section of the rami communicantes with removal of the posterior root ganglion will be justifiable in a few cases in which paravertebral injection with novocain is unavailing and in which recurring attacks of severe intractable biliary colic which do not have a clear etiologic or pathologic explanation continue. Rarely one is confronted with a patient in whose treatment all the above procedures prove ineffectual. Under extreme circumstances transduodenal approach to the major papilla and a plastic operation on the sphincter of Oddi may be necessary. Transplantation of the common bile duct has been done in order to permit free biliary drainage without obstruction owing to a spastic condition of the biliary sphincter. The immediate risk of this procedure does not justify its utilization unless all other measures have failed and unless the patient's symptoms are such that he is unwilling to endure them longer.

#### SUMMARY AND COMMENT

From a therapeutic standpoint the gall bladder may be said to be the mischief maker of the biliary system for its removal when diseased usually brings about remedy or cure. Relief follows cholecystectomy not only because of removal of the diseased gall bladder but also because of the physiologic changes brought about in the biliary tract

that permit spontaneous recovery from an infection remaining in the regional tissues. However, numerous studies have revealed that from 2 to 10 per cent of patients with definite gross lesions in the biliary tract are not relieved by operation and that this is largely due to cholangitis, hepatitis and pancreatitis which fail to subside following extirpation of the gallbladder. Gross indiscretions in diet may also be an important factor. It must be remembered, however, that benign unrelated lesions may be responsible for recurrent symptoms. Hemolytic jaundice is an occasional accompaniment of gallstones and of course fails to disappear following their removal. Carcinoma of the ducts or gallbladder may develop shortly after operation but presumably this is purely coincidental. Finally, parietal neuralgia, renal and gastric colic and angina pectoris may be responsible for symptoms that seem to be referable to the biliary tract.

If attacks of severe colic following cholecystectomy continue to occur regardless of carefully planned conservative treatment which has been carried out for a reasonable period of time, the cause of such attacks is most likely to be (1) insufficient drainage of the biliary tract at the time of previous operation, (2) a stone in the duct that was overlooked at the operation, (3) a calculus formed subsequently and (4) traumatic lesions of the ducts and adhesions, although the last should not be incriminated until all other causes are eliminated, including the possibility that the original diagnosis was not correct. Fortunately, stricture of the ducts from trauma during the cholecystectomy is not as common a cause of failure as other conditions, but when this does occur it offers formidable problems. Deaver has emphasized two other factors that lead to poor results: (1) long-standing and extensive inflammatory lesions of the biliary tract which have caused irreparable injury to other organs such as the liver, pancreas and heart, and (2) lack of ability on the part of the surgeon to select the type of operation best suited to the lesion that is present in the biliary system. If severe attacks of colic following cholecystectomy continue to occur, it may be necessary to establish prolonged drainage of the biliary

tract through the insertion of a T tube into the common bile duct in order to obtain control of the situation. In some instances because of persistence of infection or reformation of calculous debris and recurrence of symptoms it may be found to be imperative to perform choledochostomy a second time.

An operation can be held responsible for improvement in a patient's condition only if the improvement persists for a reasonable period of time or if it becomes permanent. Complete removal of stones from the biliary tract, the extirpation of a markedly diseased gallbladder or the skillful performance of any required procedure should afford relief from the more severe symptoms and should eventually result in cure in a high percentage of cases. Substitution of cholecystectomy for cholecystostomy whenever possible would result in the greatest single reduction in the number of secondary operations required in the biliary tract. The relief obtained by cholecystectomy in cases of clinical cholecystitis seems to be in definite ratio to the severity of the pain and other symptoms characteristic of cholecystitis. If the history indicates that there has been dyspepsia of obscure origin particularly without pain but associated with neurosis, nervous exhaustion or migraine the chances of cure following removal of the gallbladder are poor. Making allowances for individual interpretations of what constitutes a good or a fair result, however, it is found that 80 per cent of the patients with definite disease in the biliary tract will be relieved of their symptoms if the proper treatment is carried out and the condition of an additional 10 per cent should be definitely improved.

F. STAHR JUDD

Revised by HOWARD K. GRAY

*Papillomas*—Most of the benign tumors are papillomas but all except a few of these consist merely of hyperplastic villi which are laden with cholesterol esters and not cholesterol itself (Boyd). In this respect they resemble the hyperplasia of villi occurring in the strawberry gallbladder which has been described by Moravrian and MacCarty. This type of papilloma is small (1 to 5 mm. in diameter) and frequently multiple. It appears that infection and metabolic disturbances are the etiologic factors in the development of the tumors. MacCarty encountered this type of tumor in 4 per cent of 5000 gallbladders removed at the Mayo Clinic. There are two other types of papillomas, each of which is exceedingly rare. One of these is a soft waxy friable mass which may fill the entire gallbladder while the other appears to have a more solid base with small papillae covering the surface in a way which gives the tumor a cauliflower-like appearance (Henry). There does not appear to be any relation between these papillomas and carcinomas of the gallbladder except that papillomas may on rare occasions be precursors of carcinomatous growths.

*Adenomas*—This type of tumor is less commonly encountered than papillomas. Wellbrock found 69 instances in 9550 gallbladders removed at the Mayo Clinic. All but 4 were located in the fundus and 2 of them were malignant. Characteristically they are small nodules (1 to 10 mm. in diameter) which are palpable in the wall of the gallbladder but protrude beyond the level of the mucosa. In his series Wellbrock excluded the cystic and papillomatous tumors and included only those with glandular structures within the wall of the gallbladder.

of Benign Tumors.—It is quite clear that none of the benign tu-

Kirklin has been able to diagnose them by cholecystography provided of course a shadow of the gallbladder has been obtained. It is a significant and somewhat unexplainable fact that most benign tumors although they accompany cholecystitis are rarely found in a gallbladder which is badly diseased.

**Treatment**—The treatment of benign tumors of the gallbladder is not a very significant feature since few of them produce symptoms. The tumors are of course eliminated by cholecystectomy which is indicated perhaps because of the symptoms produced by the accompanying cholecystitis. It is obvious that on rare occasions when vague dyspeptic symptoms are present along with a gallbladder which appears to be functioning quite normally from the cholecystographic standpoint the demonstration of a benign tumor by cholecystography would be sufficient to justify cholecystectomy.

#### MALIGNANT TUMORS OF THE GALLBLADDER

Studies made by Kaufman many years ago revealed that about 5 per cent of all carcinomas encountered at autopsy were located in the gallbladder. Several years later Lam reported that U. S. vital statistics for 1936 revealed an incidence of 4.5 per cent. The writer would prophesy that now (1945) the incidence of carcinoma of the gallbladder in the total group of carcinomas would show a further decline because (1) gallstones are being removed earlier than they were twenty five or thirty years ago and (2) the incidence of some other carcinomas notably carcinoma of the lung has increased markedly in the last decade. Carcinoma of the gallbladder is encountered three or four times more frequently in women than in men. Statistics vary considerably as to the incidence of gallstones in primary carcinoma of the gallbladder (50 to 100 per cent). The average of ten large series reported recently was 78 per cent.

The importance of cholelithiasis in the development of carcinoma of the gallbladder can be more readily appreciated when the fact is considered that from 4 to 14 per cent (Rollston and McNeely) of all cases of cholelithiasis are associated with carcinoma. In 12.3 per cent of 502 cases of gall

stones encountered at autopsy Fawcett and Rippmann found that carcinoma of the gallbladder was present. Graham and associates found that at Barnes Hospital 8.5 per cent of all proved cases of cholelithiasis (operation or necropsy) were associated with carcinoma of the gallbladder or bile ducts. In only 2 per cent of over 15,000 cases of cholelithiasis reported by Judd and Gray was carcinoma of the gallbladder or bile ducts (as demonstrated by operation) present. From these figures it is obvious that there is considerable discrepancy in the incidence of carcinoma of the gallbladder in cholelithiasis. However the writer is of the opinion that a figure of between 4 and 5 per cent arrived at by Mohardt after a study of innumerable reports represents a fairly accurate estimation of the incidence of carcinoma in cholelithiasis. This corresponds closely to a recent series of 13,330 autopsies reported by Kirschbaum and Kozoll who found carcinoma of the gallbladder or extrahepatic bile ducts in 4.9 per cent of bodies revealing cholelithiasis. The incidence of carcinoma of the gallbladder or bile ducts in cholelithiasis should of course be higher in an autopsy series than in a series of operations since the patients in the latter series will be younger.

In summarizing the clinical importance of the relation of carcinoma of the gallbladder to cholelithiasis it appears safe to conclude that cholecystectomy as a prophylactic against carcinoma of the gallbladder is not a justifiable procedure. However numerous borderline cases will be encountered in which symptoms are so mild that a decision as to advisability of operation will be difficult to make. In this group it appears justifiable to allow the danger of development of carcinoma to influence one in recommending cholecystectomy particularly if the life expectancy of the patient still extends over a period of many years.

**Pathology**—Ewing has classified carcinomas of the gallbladder grossly into (1) villous, papillomatous or fungating (2) gelatinous and (3) diffuse flat, infiltrating types. Structurally or microscopically he divides them into (1) adenocarcinoma (2) alveolar carcinoma and (3) squamous cell carcinoma. The adenocarcinoma which is the most frequent form may produce papillary gelatinous or scirrhous tumors. The characteristic feature is the production of glandular structures with high columnar cells exhibiting mucus

and the other features typical of carcinoma. Associated with this type of cellular growth will be found pseudoglandular structures with cuboidal cells. A variable amount of connective tissue is present. There is usually a profuse distribution of lymphocytes, especially because of the presence of chronic infection within the wall of the gallbladder. The alveolar type is made up of pseudoglandular or columnar structures; the cells of which may be more cuboidal. Squamous cell carcinoma is the least frequent (10 to 18 per cent) and is composed of cells which may be flattened and attain squamous characteristics because of metaplasia presumably caused by extended irritation created by the gallstones. Practically all malignant tumors of the gallbladder invade the wall rapidly and extend either into the liver or along the lymph nodes of the hilus early in the disease.

Frequently the tumor arises in the proximal portion of the gallbladder or cystic duct. In such instances growth is apt to take place into the lumen of the gallbladder or downward into or along the common duct. At operation it may be impossible to discover at what point the tumor arises unless the tumor is of recent origin.

**Clinical Manifestations.**—Unfortunately symptoms of carcinoma of the gallbladder rarely manifest themselves until the late stages of the disease. Since cholelithiasis is such a constant accompaniment and precursor of carcinoma there will usually be symptoms of gallbladder disease such as dyspepsia, epigastric discomfort and pain in the right upper part of the abdomen of many years duration. From the history one can rarely tell when the carcinoma itself developed except that pain in the right upper quadrant which will be present in over half the cases will be more constant than it was when produced by cholecystitis or cholelithiasis alone. Nausea and vomiting are fairly common. Loss of weight will be noted in about one third of the cases when the patient is first seen and of course will be universal in the late stages of the disease.

In about half the cases a mass will be palpable in the region of the gallbladder when the patient is first seen. Rarely will the in duration associated with the tumor be palpated with sufficient accuracy to be of much aid in diagnosis. Metastasis takes place early and extends first to the liver and then to lymph nodes and the surrounding organs. The omentum, duodenum and colon are usually densely adherent to the involved gallbladder even before metastases are extensive.

Jaundice will be present in perhaps one third of the cases; its incidence will naturally

increase with the duration of the disease. Except on rare occasions when severe hepatitis may be present with the tumor the jaundice will be of the obstructive type produced by compression of the intrahepatic bile ducts or the extrahepatic bile ducts (i.e. the hepatic or common duct) by the invading tumor. Obviously the stools are more likely to be pale and acholic if the obstruction is caused by infiltration or glandular metastases along the hepatic duct than if the jaundice is caused by metastasis to the liver alone. The fact that jaundice produced by carcinoma of the gallbladder is persistent and progressive should differentiate it quite readily from the intermittent type of jaundice usually associated with stones in the common duct. The type of jaundice would however be of no value in differentiating the disease from carcinoma of the pancreas and primary carcinoma of the liver.

The differential diagnosis may be so difficult that it cannot be made without performing a laparotomy. Furthermore metastases occur so early that operative removal of the tumor is usually impossible at least by the time clinical manifestations point to the correct diagnosis. However the condition is confused with stones in the common duct so frequently that the surgeon is usually forced to operate lest he be guilty of failing to give the patient the advantages to be derived from a laparotomy when stones are producing the jaundice.

**Treatment.**—As previously intimated the onset of the disease is so insidious and the appearance of metastases so rapid that by the time the patient comes to operation the condition is hopeless so far as operability is concerned. Occasionally however a gallbladder is removed for chronic cholecystitis and after removal it is discovered that a very early carcinoma is present. In such a case it would appear that a favorable prognosis could be given the patient but this is not true. Occasionally a carcinomatous gallbladder can be removed satisfactorily only by removing a wedge-shaped piece of liver with the gallbladder. It is possible that utilization of this principle might increase the probability of cure. Röntgen therapy may be instituted but very few of the carcinomas of the gallbladder are sensitive to radiation.

## BENIGN TUMORS OF THE BILE DUCTS

These tumors are classified either as papillomas or as adenomas. Because of an apparent confusion in the literature it is difficult to determine which is the more common but tumors of the adenomatous type appear to be more frequently reported. Each of them is quite rare however. The adenomas as well as papillomas are usually single but may be multiple and may arise in the gallbladder (Henry). The tumor is usually small but occasionally becomes large and undergoes transition with degeneration into a cystic or myxomatous tumor. The symptoms produced by such tumors are atypical and a diagnosis is difficult to make preoperatively. When the tumor becomes large enough to obstruct the duct it is of course accompanied by jaundice and other obstructive signs depending on its location.

## MALIGNANT TUMORS OF THE BILE DUCTS

Invasion of the bile ducts by malignant tumors is more common than invasion by benign tumors and occurs in the intrahepatic as well as extrahepatic ducts. When occurring in the intrahepatic ducts they are classified as primary tumors of the liver but comprise only a small part of these tumors. Almost all malignant tumors of the bile ducts are carcinomas usually of the adenomatous type with cylindrical cells and occur more often in men than women (ratio of 4 to 3) in contrast to the greater frequency of carcinoma of the gallbladder in women. Stones are less common than in carcinoma of the gallbladder. In a study of 464 cases of carcinomas of the biliary tract encountered at the operating table Gray and Sharpe found 291 located in the gallbladder, 119 in the bile ducts and 54 in the ampulla of Vater.

In a series of 81 cases studied by Rolleston and McNece 28 occurred at the junction of the cystic and common duct, 23 at the lower end of the common duct, 19 in the common hepatic duct and 11 in the middle part of the common duct. They are usually small and nodular but occasionally infiltrate the entire duct and form a tubular stricture. The growths are associated with so much fibrous tissue that the malignant nature of the tumor may be overlooked even in

the microscopic sections. Metastases occur slowly. Cholemia associated with the obstruction is one of the major factors in the fatal outcome.

Carcinoma occurring at the ampulla of Vater may not be a true tumor of the bile duct. After the tumor has attained a certain size it is difficult to tell whether it has arisen from the ampulla, the common duct or the duct of Wirsung except that microscopically the tumors which arise in the latter sites are made up of columnar and pheroidal cells respectively. Carcinoma of the ampulla of Vater is particularly slow to invade and is therefore very amenable to treatment (i. e. excision) although the operation itself is quite formidable.

The clinical manifestations of carcinoma of the bile ducts are so inconsistent that an accurate preoperative diagnosis is rarely made. Usually the first symptom is the insidious development of jaundice associated with dyspepsia and perhaps a slight amount of upper abdominal pain. If the obstruction is complete the urine contains bile and the stools are acholic. The jaundice is usually constant and rarely diminishes after being present for a few weeks. Malaise and loss of weight are prominent. The symptoms in fact resemble closely those associated with carcinoma of the pancreas. The condition may be confused with stones in the common duct but the latter disease is usually associated with more severe pain and fluctuation in the depth of jaundice.

When the tumor is located at the ampulla of Vater the symptoms will not be different from those just described. Liver function tests may be helpful in the differentiation of obstructive jaundice of this type from intrahepatic jaundice since the tests are apt to be negative in the former group and positive in the latter i. e. intrahepatic jaundice.

The treatment of tumors of the bile ducts is of course surgical if any hopes are entertained as to permanent relief. Occasionally it will be possible to resect the tumor and to effect an end to end anastomosis with the two ends of the duct perhaps over a vital hum tube. More frequently the tumor will be located at the ampulla of Vater. If it is confined to the region of the ampulla resection as popularized by Whipple will be

indicated. Numerous technics have been devised. The resection may be performed in two stages although there is a tendency in recent years to utilize a one stage procedure particularly if a lot of blood is available for transfusions, the method suggested by Trimble and associates consisting of resection of the duodenum and head of the pancreas with anterior gastrojejunostomy and implantation of the terminal end of the common duct into the distal jejunal loop appears very practical. The various methods have been discussed in detail in the splendid monograph by Brunschwig. Palliative procedures such as the anastomosis of the gallbladder to the duodenum or the stomach may be resorted to when resection is not feasible.

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### STRICTURE OF THE BILE DUCTS

**Etiology.**—The causes of stricture of the common and hepatic bile ducts in order of frequency, are operative injury, adenocarcinoma, diffuse inflammation of the biliary tract and in a few instances benign tumor of the biliary tract such as fibroadenoma or neurofibroma.<sup>1</sup>

**General Considerations.**—The report of a case of stricture of the common bile duct by W. J. Mayo<sup>2</sup>

in 1900, in which an accurate anastomosis was made between the stump of the duct above the stricture and an opening made in the duodenum laid the foundation for the development of plastic surgery of the common bile duct for the relief of stricture. This contribution became notable because of the excellent results that followed proper execution of the method over a period of a quarter of a century.

That most of such strictures are caused by injuries to the bile ducts needs no further proof. In a series of 99 cases reported by Walters and Lewis,<sup>3</sup> cholecystectomy had preceded the formation of stricture 77 times, cholecystectomy and choledochostomy 13 times, cholecystostomy 6 times and cholecystogastrostomy with choledochostomy once. In 1 case operative procedure had not preceded the discovery of a stricture. Reports that extensive contractures of the ducts have occurred as a result of infection either in the biliary passages or in adjacent structures in cases in which operation had not been performed previously can be found in the medical literature. The possibility that a spontaneous biliary stricture may be carcinomatous is illustrated by Hings case reported by Riggs in which three months after excision of a stricture at the lower end of the common bile duct and choledochoduodenostomy jaundice again appeared. A mass in the region of this biliary stoma proved to be carcinomatous. Examination of a specimen of the stricture that was removed previously after painstaking and careful search revealed the presence of malignant cells. Rolleston was of the opinion that in Andral's case of inflammatory stricture of the common bile duct which was reported in 1831 the lesion probably was carcinomatous. A perforated duodenal ulcer strangling the duct with the products of inflammation was reported in 1876 by Morgan who also stated that in 1860 Holmes had presented before a pathologic society in London a case in which a stricture was supposed to have been caused by the passage of a stone from the common bile duct. If such did occur the possibility that the stone fretting away at the walls of the duct produced ulceration seems more likely to have been the cause than passage of the stone. Bristow<sup>4</sup> reported a case of stricture of the intestinal portion of the common bile duct that he thought might have been syphilitic and he substantiated his belief by demonstrating extensive small round cell infiltration surrounding the bile ducts. Two cases of fibroadenoma in the stump of the cystic duct, in which the typical symptoms of obstruction of the common duct were produced were reported by W. J. Mayo<sup>2</sup> in 1916. A somewhat similar type of case (neuroma) was reported on by Comfort and Walters<sup>5</sup> in 1931. Although subsequent to operation there were present in this case some slight evidences of biliary obstruction when the patient was reexamined in 1933 she had been free from symptoms of obstruction for two and a half years. A report from her in 1939 indicated that since her last examination she had experienced some attacks of recurring biliary obstruction.

Prior to 1914 strictures of the common and the hepatic bile ducts were reported for the most part as single cases. In 1914 Jacobson<sup>6</sup> reported 1 case of his own and reviewed 31 others reported in the literature. He directed attention to the various methods used in

the repair of the strictures as well as to the immediate postoperative results Ellsworth Eliot Jr.,<sup>5</sup> in 1918, reported 3 cases of stricture of the hepatic and common bile ducts in which he performed surgical operations. He also made an exhaustive review of the literature and grouped the cases according to the methods of treating the stricture. The results were recorded in each case. In 1930 he<sup>2</sup> summarized the results of various types of operations performed by many surgeons in the United States and abroad.

McArthur<sup>10</sup> in 1923 and Douglas<sup>11</sup> in 1926 reported several of their own cases. Judd and Burden<sup>12</sup> in 1929 reported the results of operation in 18 cases of stricture of the common and hepatic ducts in which operation had been performed and in 1931 Walters<sup>13</sup> presented the data on the results obtained from various operative procedures for stricture which he had carried out in 50 cases at the Mayo Clinic during the period from 1924 to 1931 inclusive. By 1936 the number of cases had increased to 51 (reported by Nygaard, Stellan and Walters<sup>14</sup>) and in 1938 Walters and Lewis<sup>15</sup> reported an increase in the number of cases to 73. The mortality rate in these last 22 cases was 9 per cent. In 1940 Walters and Lewis<sup>1</sup> reported that Walters had operated for stricture of the bile ducts in a total of 98 cases with a mortality rate of 10 per cent. The introduction and use of vitamin K (Butt and others<sup>16</sup> 1935) and bile salts in the preparation and postoperative treatment in such cases which has reduced postoperative bleeding to a minimum has been largely responsible for this reduction in the mortality rate.

Burden<sup>17</sup> and Counsellor and McInloe<sup>18</sup> have made interesting contributions to the knowledge of the stricture size and condition of the biliary tract in health and in disease. In a study of the pathologic anatomy of the bile ducts their summary includes the following statement:

"The most frequent pathologic changes in the ducts are those of inflammation. Cholecystitis nearly always is accompanied by infection in the walls of the ducts. The lesions are those of the usual chronic inflammatory type characterized by lymphocytic infiltration and the production of fibrous tissue. The glands may retain their form and all in its dissemination through the duct. The glands respond to the irritation by an overproduction of mucus and become dilated and cystic. The process of repair is attended by the formation of fibrous tissue which results in a thick and inelastic tube."

Judd and Counsellor<sup>19</sup> called attention to the fact that general obliterative cholangitis may exist months before signs of stricture appear. They noted that strictures of the common bile duct differed from those following simple aseptic ligation in that the infective process was already present in the ducts prior to the operation at which injury was inflicted. The retained bile is rapidly infected and exacerbatation of acute cholangitis follows. Although moderate dilatation usually occurs it is rarely extensive and may be entirely absent.

*Operation on the Extrahepatic Biliary Tract*—This condition is characterized usually by prolonged drainage of bile from the incision which may continue for a period of weeks or months. When the drainage of bile finally ceases jaundice occurs. As a rule this is followed by pain which is usually intermittent and colicky and which may be accompanied by chills and fever and by increasing jaundice. If stricture is complete the biliary fistula may recur, pain and fever subsiding with the discharge of bile. If stricture is incomplete the symptoms of biliary obstruction subside with discharge of bile past the region of stricture into the duodenum. Jaundice in either type of stricture varies according to the degree of obstruction in most cases tending to be constantly present in varying degrees. The serum bilirubin value (van den Bergh) varies similarly. The general systemic effects of both incomplete and complete stricture are due principally to the effects of biliary obstruction and cholemia and associated intrahepatic infection and are characterized in addition to the symptoms mentioned by loss of weight and secondary anemia. Pruritus is usually present.

*2 Carcinomatous Obstruction of the Common and Hepatic Ducts*—Malignant obstructions of the common bile duct occur with comparative infrequency. Judd, McIndoe and Marshall<sup>20</sup> cited Keisner<sup>21</sup> as observing but 2 instances in 4,578 routine post-mortem examinations and McGinn<sup>22</sup> found 5 in 9,000. Of 22,000 operations on the biliary tract at the Mayo Clinic, 41 were performed for carcinoma of the bile ducts. Such malignant lesions occur infrequently and produce a high mortality rate. The results of any type of operative procedure on the biliary tract in which such malignant strictures are present are poor.

The lesion occurs more commonly among males than among females and in about 50 per cent of the cases there are associated stones in the gallbladder or in the bile ducts. Although the tumor may be found to involve any portion of the common or hepatic bile ducts it most frequently occurs either at the junction of the cystic and common ducts or at the division of the hepatic duct into its main branches. Rarely is the lesion localized sufficiently to be excised. One pa-

## Symptomatology and Pathology.—

### 1 Stricture of the Common Duct Follow-



tient who was operated on for such a lesion by W. J. Mayo in 1904 was living and well in 1917.

The clinical picture produced by carcinoma is not different from that produced by any other type of obstructing lesions of the common bile duct although when obstruction occurs the jaundice is likely to be painless more frequently than otherwise. Biliary obstruction which occurs as a result of a malignant lesion of the common or the hepatic bile duct is characterized by the development of progressively increasing jaundice. At first when the lesion is small the obstruction may be incomplete producing attacks of intermittent pain associated with fever. In this stage of the obstruction it is impossible in most cases to distinguish the condition from that which results from a benign obstructive lesion that is mainly stone in the common duct. When biliary obstruction becomes complete as a result of malignant obstruction of the common and hepatic ducts as in biliary obstruction due to carcinoma of the head of the pancreas the level of serum bilirubin in the blood reaches a much higher level than in cases of benign obstruction and occasionally reaches a concentration of 25 mg. or more per hundred cubic centimeters.

The general condition of the patient as regards weight, anemia and pruritus closely parallels that of any other patient who has a similar degree of jaundice regardless of the type of biliary obstruction.

3. *Stricture Due to Diffuse Inflammation of the Biliary Tract*—This condition occurs with extreme rarity. With but 1 exception patients suffering from benign stricture of the common bile duct on whom Walters has operated have presented histories of having previously undergone operative procedures on the biliary tract. The symptoms in cases of this type usually appear insidiously with evidences of disease of the biliary tract and minor degrees of biliary obstruction. The picture is similar to that of cholelithiasis disease occurs and is followed later by biliary colic associated with jaundice. The attacks of pain and the depth of jaundice increase as the inflammatory lesion progresses to cause more nearly complete obstruction. In the early stages of obstruction of this type bile can be obtained on duodenal drainage

which decreases progressively as the obstruction becomes more nearly complete.

4. *Stricture Due to Benign Tumor of the Biliary Tract*—This condition manifests symptoms similar to those of stone in the common duct obstructive symptoms depending on the degree of obstruction caused by the tumor.

**Differential Diagnosis.**—Symptoms from lesions of the common and hepatic ducts are dependent on the degree of biliary obstruction and the presence or absence of cholangitis regardless of the pathologic character of the lesion. For this reason it is difficult in most cases to distinguish between benign and malignant strictures of the ducts. It is similarly difficult preoperatively to distinguish between biliary obstructions due to stricture and those due to stone when the patient has undergone a previous operation on the biliary tract. When there has not been a previous operation stone is the more likely cause especially since spontaneous inflammatory strictures of the ducts are rare. One important exception is noteworthy and that is the frequency with which abnormally prolonged drainage of bile from the incision subsequent to operation on the biliary tract is evidence of injury to the duct which sooner or later is followed by stricture.

If a patient presents himself with an external biliary fistula having been operated on elsewhere before transplantation of the fistula is considered the condition of the common and hepatic bile ducts and of the gallbladder should it remain must be ascertained. For example if material resembling the white of egg is excreted the probabilities are that the gallbladder remains and that there is a stone in the cystic duct. When bile is excreted the probabilities are that the obstruction is in the common bile duct and that it is caused by stone by stricture or by a tumor in the head of the pancreas. In most cases the outline of the ducts can be obtained by roentgenographic examination of the region after the injection of radiopaque substances (lipiodol and brominol) through the sinus into the ducts. In some cases however visualization may not be satisfactory and it will be necessary to determine the length of the common or hepatic duct remaining above the stricture at the time of reoperation.

**Medical Treatment.**—Medical treatment consists largely of relief of pain and preparation of the patient for operation. When an external biliary fistula is present, an effort should be made to return the bile to the digestive tract by mixing some of it with such dietetic liquids as grape juice. One patient who had an external biliary fistula from carcinoma of the ampulla took bile mixed with grape juice daily for more than a year. In some cases bile has been diluted and given by proctoclysis, in general however it is irritating and uncomfortable to the patient and especially so when administered by proctoclysis. The control of pruritus is a difficult matter. The proper application of lotions and the administration of *Urtica* hypodermically are of some aid. Intravenous injections of small dilute quantities of procaine will at times give a brief respite from severe intractable pruritus.<sup>21</sup>

but even so the incidence of serious postoperative hemorrhage in such cases is rare. Three thousand cubic centimeters of fluids are given orally, intravenously or by proctoclysis daily infusions of 1000 to 2000 cc of 10 per cent glucose in physiologic salt solution also are administered and a high carbohydrate diet is employed. In cases of profusely draining fistulas the concentrations of the blood urea and of electrolytes should be determined and any imbalance should be restored to as nearly normal level as possible. If a patient is deeply jaundiced and there is difficulty in controlling the hemorrhagic tendencies with vitamin K a preoperative transfusion of 500 cc of freshly drawn blood is given. It has been shown that the prothrombin content of stored blood fall rapidly.

(b) *Operative procedures for benign strictures can be divided into five groups* (1) hepaticoduodenostomy

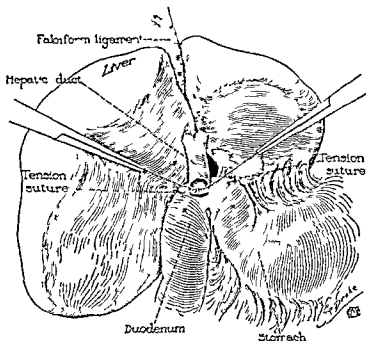


Fig 609—Cholechooduodenostomy with end to side anastomosis

**Surgical Treatment**—(a) *Preoperative treatment* consists of the administration of abundant fluids vitamins especially thiamine chloride and vitamin K (orally and parenterally) the intravenous injection of glucose and in an occasional case transfusions of blood in an attempt to improve hepatic function and to decrease the prolonged coagulation time of the blood caused by the disturbances of hepatic function and the deficiency of prothrombin.<sup>22</sup> Clinical data indicate that certain naphthoquinones which have been designated as synthetic vitamin K increase the prothrombin content of the blood in cases of jaundice and decrease the hemorrhagic tendencies of jaundiced patients. The use of synthetic vitamin K substances (naphthoquinones) has permitted rapid increase in the prothrombin content of the blood when these compounds have been administered intravenously. In some cases when extensive hepatic damage is present administration of vitamin K in any form will not have as beneficial effect on the prothrombin as in other cases,

cholechooduodenostomy (Fig 609) and cholecystoduodenostomy (Fig 610), (2) excision of the strictures or tumor with anastomosis of the ends of the duct (3) plastic operation for localized stricture which consists of longitudinal incision of the stricture followed by transverse closure after the method of a Heineke Mikulicz pyloroplasty (4) transplantation of an external biliary fistula established when a sufficient amount of common or hepatic duct does not remain to permit anastomosis of the duct and the duodenum and (5) resection of the ampulla of Vater for carcinoma.

The following general considerations will guide in the selection of the surgical procedure.

1. The permanent implantation of a vitallium tube in the treatment of injury or stricture of the bile ducts as advocated by Pearse,<sup>23</sup> constitutes an important contribution to this type of surgery. Pearse advises using a straight 33 cm by 6 mm tube with a central flange to anchor it in place in order to hold open a

stricted area of the common bile duct. For a stricture of the common hepatic duct within 1 cm. of the bifurcation of the hepatic ducts he advises using trumpet-shaped Y or half Y tubes.



Fig. 610—Cholecystoduodenostomy for stricture of the lower end of the common duct.

ention of the hepatic ducts he advises using trumpet-shaped Y or half Y tubes.

the liver is in satisfactory condition. In 34 of the 98 cases of stricture of the common duct (reported by Walters and Lewis<sup>3</sup>) in which Walters operated cholecystoduodenostomy was performed. Twenty-eight patients were well at the time the reported study was made. In the group of 34 cases there was only 1 postoperative death. 3 patients died after dismissal and 2 patients experienced recurring obstruction. Hepaticoduodenostomy was performed 31 times. In this group of cases only 13 patients were well at the time the study was made. Two patients died postoperatively and 8 died after dismissal. Eight patients had recurring symptoms. In 4 of the series of 98 cases stumps of both the right and the left hepatic duct were discovered above the strictured common hepatic duct and common bile duct. The stumps were anastomosed separately to the duodenum over rubber tubes of the Mayo-Sullivan type (Fig. 611).

Failure to obtain a good result with any of these methods can be attributed directly to inaccurate anastomosis to severe infection of the parenchyma of the liver or to infection in the walls of the biliary tract itself. Infection in either of the structures mentioned may be accompanied by sand-like calculi within the biliary passages.

3. If the stricture or tumor is small or if it is situated directly adjacent to the liver with normal duct both proximal and distal to it, excision of the lesion with subsequent direct anastomosis of the ends of the duct probably will be a satisfactory procedure and can be expected to be followed in many cases by good results. Such is not usually the case, however, if the scarred portion is merely incised and allowed to remain, even though the lumen of the duct at this point

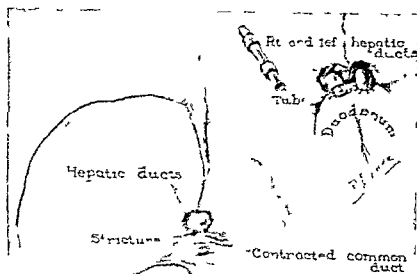


Fig. 611—Method of separate anastomosis of the right and left hepatic ducts to the duodenum.

• If sufficient normal duct remains above the stricture to permit its accurate anastomosis without tension to an opening made in the duodenum, thus obtaining union of mucous membrane to mucous membrane (Fig. 609) results will be excellent provided

is increased by a plastic procedure of the Heineke-Mikulicz type. This failure may be explained by the fact that the remaining scar tissue continues to contract. In 11 of the 98 cases in which Walters operated he performed some form of plastic operation on the

bile ducts One patient died within a short time post operatively and 2 died subsequently of the 11 patients who underwent plastic procedures 6 were well and 2 had had recurring attacks of jaundice

denum This procedure may be expected to be followed by good results in some instances and by fairly good results in others This operation however is the least satisfactory of the methods outlined and recur

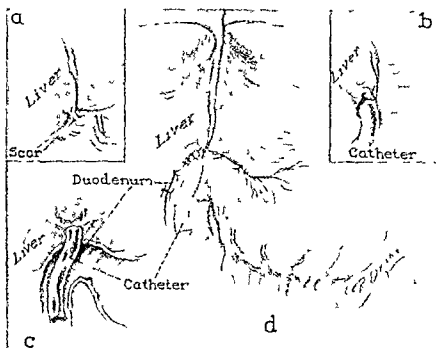


Fig 612—Establishment of an internal biliary fistula in a case of complete stricture of the extrahepatic ducts

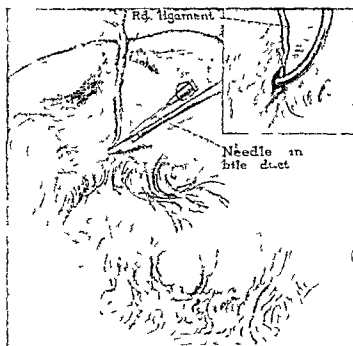


Fig 613—Exploration of the hilum of the liver with an aspirating needle which then is used as a guide for the scalpel. A catheter is inserted into the duct for drainage

4 If the amount of duct that remains exterior to the liver is not sufficient to allow for either procedure, an external biliary fistula can be established and later coned out and transplanted into the stomach or duo-

denum In the group of cases in which it is used are high This method was employed in 9 cases with satisfactory results in only 2 although there was only 1 death during the postoperative period

A more satisfactory type of operation is the immediate suture of an opening in the duodenum about the hilum of the liver. This procedure is carried out after a dilated duct is discovered in the hilar region of the liver. A short catheter is inserted into an opening made in the duct and a small opening in the duodenum in the shape of a fish mouth then is sutured about the catheter to the hilum of the liver.

In December 1938 Walters operated on a woman aged twenty-six years for complete stricture of the extrahepatic ducts using a procedure such as that described in the preceding paragraph (Fig 612). The patient received considerable relief although occasional attacks of subacute incomplete biliary obstruction occurred subsequently.

If transplantation of an external biliary fistula is deemed the procedure of choice it must adequately



Fig 614—Spontaneous communication of an external biliary fistula with the duodenum caused by pressure necrosis of an indwelling catheter.

drain the intrahepatic ducts and these ducts must be free of stones otherwise the obstruction will recur. Furthermore the possibility of a more certainly curative type of operative procedure, namely hepaticoduodenostomy, should be considered if sufficient normal duct remains above the stricture or the fistula to enable the duct and the duodenum to be accurately anastomosed.<sup>24</sup>

In 18 of the 99 cases reported by Walters and Lewis extrahepatic ducts could not be found. In such cases the following technique permits discovery of a dilated intrahepatic duct. An aspirating needle is introduced into the region of the hilum of the liver until bile is obtained. A small scalpel on a long handle then is introduced alongside the needle which is left in place to act as a guide (Fig 613). The opening into the duct is enlarged to permit the introduction of a good-sized catheter (20 to 26 F). In 17 of the 18

cases this method or a modified procedure permitted the establishment of an external biliary fistula. In 2 cases in which external biliary fistulas were formed the pressure necrosis of an indwelling catheter produced a spontaneous communication between the fistula and the duodenum. In 1 of these cases the spontaneous communication (Fig 614) developed about nine months after the operation and two years later this patient was enjoying good health.

a The frequency with which small tumors of the ampulla of Vater cause obstructive jaundice should not be forgotten. Since the tumor is usually small and is of a low degree of malignancy, producing symptoms early and metastasis late it lends itself readily to transduodenal removal. Rarely the tumors are benign.

In a consideration of the various methods of operation for tumor of the ampulla of Vater, it is only fair to give credit to palliative or conservative methods of relieving obstruction by anastomosis between the biliary and intestinal tracts and to call attention to Abell's<sup>25</sup> interesting case in which radium was applied by an ingenious method to the ampullar lesion. If the patient is deeply jaundiced or if his condition is such that resection of the ampulla cannot be accomplished with a reasonable margin of safety, it would seem that the palliative operation of biliary intestinal anastomosis is indicated.<sup>4</sup> On the other hand if the patient is in good condition and the lesion is producing such symptoms as bleeding which may terminate the patient's life unless it is stopped, it would seem that resection should be undertaken. In support of the argument favoring ampullar resection in indicated cases is the relatively low malignancy of carcinomas of the ampulla of Vater. Hunt and Budd<sup>27</sup> in a review of 63 cases reported in the literature found that the risk of radical extirpation was 38 per cent of 47 survivors of radical operation. 10 had died of recurrence within one year. Cholecystostomy or more desirably cholecystogastrostomy is advisable preliminary to resection of the ampullar lesion if the patient is deeply jaundiced.

It is an interesting fact that the operative mortality rate among patients who have malignant lesions of the extrahepatic biliary passages is exceedingly high regardless of the type of surgical procedure carried out. This is true even when such a minor procedure as removing a specimen of the lesion for microscopic examination is done. Indeed it is likely to be the case also if an exploratory operation alone is carried out without excision of any tissue. The reason for this high mortality probably lies in the fact that as a result of the prolonged jaundice a considerable degree of hepatic impairment is present. In addition the effect of the malignant disease probably tends to lower the general vitality and resistance of the patient. The increasing knowledge of hepatic disease and the treatment of various deficiencies with vitamins and glucose have greatly reduced the mortality. In cases in which patients failed to recover from operation postmortem examination reveals as a rule various degrees of cholangitis and hepatitis, hepatic abscesses and destruction of hepatic cells. The use of vitamin K has diminished greatly the occurrence of hemorrhage even when considerable hepatic damage exists.

In cases of benign stricture of the common bile duct the operative risk is not nearly so great although in

any large series of cases the operative mortality rate will vary from 10 to 20 per cent. In the series of 98 cases in which Walters operated, the operative mortality rate was 10 per cent. The surgical procedures included operations on 18 patients who had complete stricture of the extrahepatic ducts. Only 1 postoperative death, however, occurred in 31 cases in which choledochoduodenostomy was performed, a mortality rate of 3 per cent. Provided it is possible to relieve the biliary obstruction completely, the risk of the operation will depend for the most part on the ability of the liver to regain its function. Relief of obstruction is the essential purpose of any operative procedure on the jaundiced patient, for unless the obstruction is completely relieved, hemorrhage or infection usually will terminate the picture, and the control of such hemorrhage, even though vitamin K is administered is directly dependent on the ability of the liver to function. Persisting postoperative infection and cholangitis frequently respond to administration of sulfanilamide and other chemotherapeutic agents. The judicious use of cholentec agents such as deLolin (dehydrocholic acid) may aid in "flushing" the biliary passages and relieving stasis and associated infection.

**Summary.**—From 1924 to 1940 Walters operated on 98 patients who had benign strictures of the common bile duct; this number included 18 patients who had complete stricture of the extrahepatic ducts. Ten patients died in the hospital subsequent to operation, a mortality rate of approximately 10 per cent. In 4 cases (before the introduction of vitamin K) the immediate cause of death was postoperative hemorrhage. A study made in 1940 revealed that of the 98 patients, 52 (53 per cent) were living and well. Of the 34 patients, however, on whom choledochoduodenostomy had been performed, 28 (82 per cent) were living and well.

In the entire series of cases, choledochoduodenostomy was performed 34 times and hepaticoduodenostomy 31 times; plastic reconstruction of the bile duct was possible 11 times. This group yielded by far the most favorable results, in that there were only 4 deaths, a mortality rate of 5 per cent. Sixty-two per cent of these patients were well in 1940 at the time the study was made.

The use of sulfanilamide has aided in the control of recurring attacks of cholangitis, and the introduction of vitamin K has reduced greatly the danger of postoperative hemorrhage.

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## CONGENITAL OBSTRUCTION OF THE BILE DUCTS

**Etiology and Pathology.**—According to Ylppo and other observers the bile ducts in their process of development pass through a solid stage analogous to that of the intestine. An arrest in development during this solid stage more adequately explains the malformations found than any of the other theories advanced.

The gross pathologic findings associated with these obstructions of the biliary ducts are general icterus, enlargement of the liver and a wide variation in the malformation of the ducts.

**Symptoms and Diagnosis.**—The diagnosis of congenital obstruction of the bile ducts may be quite difficult to make in the first few weeks of life but it becomes simpler as the infant grows older. The jaundice

is present a few days after birth and grows more intense as the infant enters the second month of life. It is of a greenish yellow tinge rather than the marked yellow seen in biliary obstruction of adult life. The stools are acholic as a rule but may at times give a positive test for bile or may show gross evidence of bile on their surface even in cases of atresia or complete absence of extrahepatic ducts. This is explained by the excretion by the intestinal mucosa of the bile carried in the blood stream. The urine contains bile and the icterus index is usually high. The bleeding and clotting time may be slightly prolonged. The fragility of the red blood cells is normal. Slight anemia has been observed in some of the patients. The patients show a surprisingly good state of nutrition and development even when several months old. The striking features are the general icterus and the enlarged liver with a hard edge.

Other diseases may be confused with this condition for instance icterus neonatorum which is not serious and which generally disappears after the second week. While the degree of icterus during the first two weeks of life may be the same as in cases of obstruction the infant with icterus neonatorum does not have an enlarged liver, acholic stools or bile in the urine. Erythroblastosis foetalis is likely to have an early fatal outcome but before death the infant usually shows an enlarged spleen and an increased number of erythroblasts in the blood smear. Jaundice of hemolytic sepsis does not show acholic stools, bile in the urine, a high icterus index or progressive jaundice. Syphilis is ruled out by serum tests of patient and parents and by roentgenograms of the bones.

With few exceptions it is better not to operate before the end of the first month. Nothing is lost by this delay and the assurance of a correct diagnosis is gained. It is not wise to put off the operation beyond the second month as these jaundiced infants have a low resistance to infections from which they may die.

**Treatment.**—The treatment is surgical. The type of operation used on the small infants varies with the lesion found. The operation is not easy on account of the small

size of the structures and their variations from normal. In case the common duct is not readily identified, it is helpful to insert a small catheter into the gallbladder and to

was theoretically amenable to relief by surgical methods. Thirteen of the 19 patients with complete obstruction whose condition was operable have recovered. The 6 patients

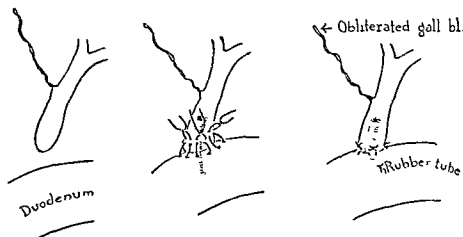


Fig 615—Atresia of the common duct, showing the technique of end to side anastomosis over a small piece of rubber tube, with a single row of interrupted mattress sutures of fine silk.\*

inject saline solution through it. If the cystic duct is patent and the common duct is not, this procedure will distend the common duct and make its isolation easier. When atresia of the common duct is demonstrated, the gallbladder may be anastomosed to the stomach or duodenum. This is a simple procedure but is not the operation of choice except when the patient's condition does not warrant the somewhat more difficult operation of choledochoduodenostomy. The common duct is so small that the ordinary methods of anastomosis are not feasible (Fig 615). Hence, it is performed over a short piece of rubber catheter, and in case of an extremely small duct a very small piece of ureteral catheter is used. For the smallest duct we have successfully anastomosed, a segment of no. 4 ureteral catheter was used. The suture material was very fine silk. The catheter is left in place to be carried on by intestinal peristalsis (see roentgenogram in Fig 616). In one instance a successful anastomosis between the hepatic duct and the duodenum was carried out in the same manner as that described for the common duct.

**Prognosis**—The mortality for the patients with complete obstruction without operation is, obviously, 100 per cent. In our series of 60 cases there were 54 cases of complete obstruction and 6 of partial obstruction. In 24 of these 60 cases the condition

with partial obstruction all recovered but 2 have had occasional return of symptoms. In this group the late results suggest that



Fig 616—Roentgenogram of the patient with atresia of the common bile duct. Note the rubber tube over which the end to side anastomosis of the common bile duct to the duodenum was made.\*

choledochoduodenostomy is preferable to cholecystoduodenostomy or cholecystogastrostomy.

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## XXXI. THE PANCREAS

### SURGICAL DISEASES OF THE PANCREAS

**Anatomy.**—The pancreas is deeply located in a retroperitoneal position behind the aetosal floor of the *omental bursa* at the level of the first and second lumbar vertebrae. It extends from the duodenum on the right to the spleen on the left. The organ may be divided into a head, neck, body and tail. The head of the organ is hooked into the loop of the duodenum. Posteriorly the head lies on the vena cava and portal tributaries while the body crosses the aorta, renal vessels, suprarenal gland and left kidney. The tail may be intimately related to the spleen. The stomach is anterior, the transverse mesocolon is inferior and at the extreme left will be found the splenic flexure of the colon. The upper margin is grooved or tunneled by the splenic artery.

**Tumors of the pancreas** may compress the inferior vena cava and portal tributaries and cause ascites. Carcinoma of the head of the pancreas usually compresses the common bile duct and causes jaundice. An ulcer on the posterior wall of the stomach may erode into the pancreas. The tail may be injured during splenectomy or nephrectomy. Solid or cystic growths will project forward through the gastrocolic or the gastrohepatic omentum or inferiorly through the transverse mesocolon. The main pancreatic duct of *Wirsung* traverses the entire length of the gland and opens into the ampulla of Vater, usually in association with the common bile duct. This is important, because if the opening into the duodenum is obstructed the bile may pass into the pancreatic duct and set up pancreatitis. An accessory duct (*Santorini*) is usually present and communicates between the main duct and the duodenum cephalad to the ampulla.

The pancreas is supplied by the splenic and superior and inferior pancreaticoduodenal arteries. The lymphatic distribution is rich and drains mostly into the pancreaticoduodenal and aortic nodes. The nerves are derived from the solar plexus and the vagus.

**Physiology.**—The pancreas is intimately concerned in the metabolism of carbohydrate, fat and protein. It is concerned with the building up, storing and preparation of energy for utilization in the tissues.

The external secretion poured into the duodenum is important for digestion by reason of its ferments (trypsin, amylase, lipase, renin, maltase and possibly erepsin). Unlike the gastric enzymes, apparently those of pancreatic juice are produced in one type of cell. Trypsin or pancreatic protease is a much more powerful proteolytic enzyme than pepsin. As secreted by the pancreatic cells, trypsin exists as the proenzyme in an almost inactive state which is converted from trypsinogen to trypsin by the enterokinase of the duodenal secretion. Conversion of trypsinogen to trypsin in the pancreas results in digestion of pancreatic tissue, presumably the mechanism in pancreatitis. Proteins are

hydrolyzed to the dipeptide, tripeptide and tetrapeptide stage by the action of this enzyme. Pancreatic amylase acts in a fashion similar to that of salivary amylase, causing rapid hydrolysis of starch. Pancreatic lipase splits the fat molecules into the constituent fatty acid and glycerin.

The internal secretion derived from the islets of Langerhans has to do with the carbohydrate metabolism, and if it is deficient diabetes results. This secretion, under the name of insulin, may be administered artificially and thus may regulate the diabetic state if assisted by proper diet.

### ANOMALIES OF THE PANCREAS

Abnormalities of the pancreas may be divided into those of the gland and those of its ducts.

An accessory or aberrant pancreas may exist in the walls of the stomach, duodenum, jejunum or ileum; the pancreas may be cleft almost into two parts; it may have outlying lobules or may by enlargement of its head almost completely encircle the duodenum (annular pancreas).

The normal arrangement of the common duct and pancreatic duct uniting to form the ampulla of Vater may be altered so that (1) the pancreatic duct joins the common duct some distance from the duodenum, the ampulla being absent; (2) the two ducts open separately into a fossa, the ampulla and earuncle being absent; (3) the two ducts open separately at the apex of the earuncle, the ampulla being absent; (4) rarely, the common duct unites with the duct of Santorini.

As to the two pancreatic ducts the rule is that both are present and they anastomose with each other; the duct of *Wirsung* is the larger. Occasionally the duct of Santorini is separate and may be the larger. In 20 per cent of bodies the duct of Santorini is obliterated near its termination (Opie) and if the duct of *Wirsung* is occluded in such a case secretion is entirely obstructed.

While a movable pancreas is practically unknown as a clinical entity, it may fall downward or forward or may be part of the contents of a diaphragmatic hernia or very rarely may be contained within the sac of an umbilical hernia.

### TRAUMATIC PANCREATITIS

**Etiology.**—Injury of the pancreas uncomplicated by severe trauma to other organs, is a rare occurrence. Forty six cases only, of subcutaneous injury, have been collected by Stuart (1921). In a study of 965 cases of gunshot wound of the abdomen, Wallace (1917) found that the pancreas was wounded five times. The pancreas is injured by a sudden, severe force that drives the or-

gan against the vertebral column and crushes it. The patient may be caught between cars, may be run over, may be kicked by a horse or may fall against the edge of a

tion. Shock or collapse occurs, and there is intense pain in the epigastrium. Rigidity is present. Nausea and vomiting occur. There may be dullness in the flanks, owing to the



Fig 617—Showing the anatomy of the pancreas and its anatomical relations \*

table. A bullet wound of the abdomen may involve the pancreas, along with other neighboring organs. Such an injury gives rise to severe shock and hemorrhage.

collection of blood. If the contusion or laceration is slight in extent, the patient may suffer few symptoms, but later a cystic swelling develops in the epigastric or left

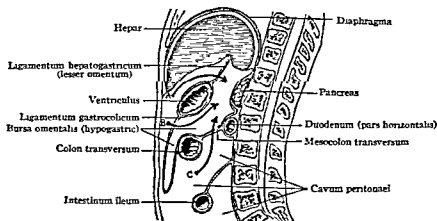


Fig 618—Sagittal section to show surgical approaches to the body of the pancreas. *A* is the approach through the gastrohepatic ligament, *B* is the approach through the gastrocolic ligament, *C* is the transmesocolic approach †

**Symptoms.**—There are no cardinal symptoms. Complicating injuries to other organs usually produce the recognizable symptoms, and the pancreatic lesion is found at opera-

tion. Shock or collapse occurs, and there is intense pain in the epigastrium. Rigidity is present. Nausea and vomiting occur. There may be dullness in the flanks, owing to the

† Callander: *Surgical Anatomy*, W. B. Saunders Co., Publishers

\* Mayo, W. J., *Ann Surg* 58 J. B. Lippincott Co

cretic fluid into the lesser peritoneal cavity and is to all intents and purposes a pseudo pancreatic cyst

**Treatment**—If the diagnosis is made or suspected if the symptoms are severe and if the condition of the patient permits the abdomen should be opened the lesser cavity exposed and the rupture tamponed or sutured. The latter is to be preferred but as a fistula almost always results drainage must be provided. If the patient recovers the fistula persists and usually closes spontaneously in five or six weeks. The exclusion of carbohydrates from the diet is often recommended but is of no material benefit. If the fistula persists indefinitely it may be necessary to reoperate and remove the distal portion of the gland.

### WOUNDS OF THE PANCREAS

Gunshot and stab wounds may occasion ally involve the pancreas alone but usually affect other organs as well. The probable course of the bullet and the locations of the wounds of entrance and exit are usually the only guides. Prompt operative intervention should be undertaken and the wound treated by suture or tampon. Drainage is always indicated.

The pancreas is occasionally injured during the performance of operations on other organs. In the operation of partial gastrectomy an adherent ulcer may necessitate shaving a part of the pancreas. No harm seems to result. Injury to the tail of the pancreas has accompanied splenectomy and unless the gland is well ligated it may result in a fatality. More serious is the injury done during the performance of nephrectomy when the clamps have grasped the pancreas. Young (1917) thinks that this accident should be suspected when the operation is followed by rapid prostration and extreme distention.

### PARENCHYMATOUS INFLAMMATIONS

The parenchyma of the pancreas may be attacked by a necrotizing inflammation hemorrhagic in character and either acute or subacute in its manifestations by a suppurative infection due to microorganisms or by a chronic interstitial sclerosing process involving the interlobular or interacinar portions of the gland.

### ACUTE HEMORRHAGIC PANCREATITIS

**Etiology**—Polva (1906) and Guleka (1904) feel that the exact mechanism concerned in the production of the acute hemorrhagic lesion is due to a sudden activation of the trypsinogen by the retroinjected bile in cases of obstruction at the papilla of Vater causing autodigestion of the gland. Dragstedt (1934) feels that the lesion is not produced by autodigestion but that the necrosis of the gland results from direct action of the bile salt present in the bile resulting in a fertile medium for the growth of organisms resident in these tissues particularly anaerobes which by their rapid growth give rise to the toxic symptoms. Rich and Duff (1936) feel that the commonest cause of acute pancreatitis is due to obstruction to the flow of pancreatic juice resulting from metaplasia of the epithelial lining of a branch of the pancreatic duct within the gland itself. The ductules and acini behind the obstruction become dilated rupture and permit escape of pancreatic juice into the glandular substance. The interstitial tissue of a pancreas is in common with the tissues of the remainder of the body possesses the power to activate the trypsinogen within the gland resulting in autodigestion. These observers have found metaplasia of the duct epithelium and acinar dilatation in 13 of 24 cases of hemorrhagic pancreatitis. In the great majority of these cases no obstruction to the main duct was found nor was there any occlusion at the papilla of Vater. It is also pointed out by these workers that rupture of the duct is most likely to occur when the intraductal pressure is greatest particularly after a meal.

A commonly discussed etiological factor is infection spreading from the biliary tract and especially the gallbladder by way of the lymphatics. There is no good evidence for believing that infective lymphangitis can spread to the region of the head of the pancreas block the exit paths from the pancreas and produce lymph stasis in the head of the pancreas with consequent pancreatitis. There is no anatomical evidence that the lymphatics of the biliary tract area do more than communicate with the pancreatic area outside the capsule of the pancreas.

The disease occurs more frequently in men than women and between the ages of

twenty and fifty. Obese persons are said to be more often affected. Usually the patient gives a history of repeated mild attacks previously or his disease of the gallbladder. Acute interstitial pancreatitis without necrosis or abscess is fairly frequently observed concomitantly with acute cholecystitis especially with empyema of the gall bladder and is no doubt the forerunner of chronic pancreatitis.

Acute hemorrhagic pancreatitis is more of a necrosis than an infection and the chocolate like fluid in the lesser cavity is usually sterile in early typical cases. The disease results from the action of liberated ferments on the surrounding tissue.

**Symptoms**—The clinical picture was described by Fitz in 1889 in these words: "Acute pancreatitis is to be suspected when a previously healthy person or sufferer from occasional attacks of indigestion is suddenly seized with violent pain in the epigastrium followed by vomiting and collapse and in the course of twenty four hours by a circumscribed epigastric swelling tympanitic or resistant with a slight rise of temperature."

The patient may have been previously in good health or may have been a sufferer for years from attacks of so called indigestion or of gallstones. Acute violent pain is the symptom of onset; it is referred to the epigastrium and is followed by nausea and vomiting. Early collapse with its attendant symptoms is usually observed and is caused by the intense pain and the rapid involvement of a great part of a vital organ. The abdominal muscles become extremely rigid and in the course of twenty four hours the epigastrium becomes tender, swollen and tympanitic. The pulse rate steadily rises, the temperature also rises if reaction from shock takes place from secondary changes in the gland. Cyanosis has occasionally been observed, jaundice may be present and is accompanied by constipation and clay colored stools.

Death may occur within twenty four hours but if the patient survives the acute stage the pancreas gradually becomes gangrenous. The symptoms subside at first but the pain persists; the epigastrium remains distended and vomiting recurs at intervals. Belching and hiccoughing are frequent symptoms. High fever, chills, leukocytosis

and rarely fatty stools and glycosuria appear in the later stages and a tumor mass may be demonstrated in the epigastrium and extending to the left.

**Diagnosis**—Acute pancreatitis is usually confused with intestinal obstruction owing to the acute onset, the cramp like pains, the distention and vomiting. But the intense shock and the localization of the symptoms in the epigastrium are of great importance in diagnosing pancreatitis. Jaundice, absence of fecal vomiting and the slight distention localized in the upper abdomen are also suggestive of pancreatitis. If the patient survives the first thirty six hours the diagnosis should not be in doubt as in intestinal obstruction there will be persistent fecal vomiting, increasing distention, constipation and signs of peritonitis.

In appendicitis the pain and tenderness may at first be felt in the epigastrium but in a few hours they become localized in the right lower abdomen. In acute cholecystitis and in biliary colic the pain is located to the right of the median line and radiates to the back and subscapular regions and the tenderness and swollen condition of the gall bladder may also be elicited to the right and beneath the costal margin. In perforating gastric or duodenal ulcer the previous history, the intense rigidity and the rapid recurrence of distention, obliterating the liver dullness are important differential points.

Estimation of the urinary diastase and blood amylase levels seems to be of value in the diagnosis of acute pancreatitis. Under normal circumstances from ten to twenty-four diastatic units are excreted in the urine daily and the values for blood amylase as determined by McCorkle and Goldman (1949) rarely exceed 180 units although Comfort (1942) has given 370 units as the upper limit of normal. An index of 900 or more diastatic units in the urine is taken as significant. Values above 180 for the blood amylase are likewise significant. The exact mechanism producing the elevation in both of these substances is unknown. It has been postulated that during acute hemorrhagic pancreatitis edema of the acini and ducts results in rupture and liberation of the pancreatic juices into the interstitial tissue with consequent absorption by the blood stream. Wohlgemuth's technic seems the best for

the determination of the urinary diastase while Samols's method for the determination of amylase is probably the best in this regard.

Recent observation indicates that pancreatic function is likewise impaired to a measurable degree by chronic inflammatory disease. Ligerlof (1939) using the two tube technic showed marked increase in secretion of pancreatic juice upon intravenous injection of secretin. In cases of chronic inflammatory and sclerosing lesions the reaction of secretin is greatly diminished while in obstructive lesions of the papilla of Vater or the head of the pancreas the flow is absent. This may help to differentiate these patients from the jaundiced patient with carcinoma of the common or hepatic ducts. Secretin increases the volume and alkalinity of the juice while methylacetylcholine increases the contents of the ferment without increasing the volume or alkalinity of the juice.

**Prognosis**—The majority of these patients die no matter what treatment is undertaken. As a general rule however early rapid operation offers fair prospects of cure if the patient is not in extreme shock. In subacute cases an abscess often develops in the lesser cavity or about the left kidney more rarely a subphrenic abscess occurs.

**Treatment**—Immediate operative treatment should be undertaken if the patient is seen in the first forty eight hours after this time it may be wise to wait until a localized collection is formed.

The incision is made in the median line above the umbilicus and the abdomen opened, the escape of bloody fluid the characteristic areas of fat necrosis and the swollen pancreas will confirm the diagnosis. The lesser cavity is then opened by tearing through the gastrocolic omentum and the pancreas is exposed. It should be incised in several directions the fluid in the lesser sac mopped out and free drainage effected by rubber tubes and gauze tampons. If an abscess has formed or there is much necrosis of the surrounding tissues a posterior stab wound in the left loin will drain the sac at its dependent portion.

The gallbladder and bile ducts must then be inspected and stones removed and drainage instituted if stones are present if there is infection of the tract or if jaundice is pres-

ent. A separate incision may be necessary for this performance. As little anesthesia as possible should be given and chilling of the patient avoided. In the after treatment the patient should be placed on an antidiabetic diet to lessen the irritation of the pancreatic secretion.

**Mild Forms of Acute Pancreatitis**—While the violent form of acute hemorrhagic pancreatitis may be taken as a type surgeons sometimes encounter an acute pancreatitis without hemorrhage. This may be an acute edema of the pancreas or there may be areas of necrosis with little or no hemorrhage. Chronic or subacute cholecystitis is associated with it.

The patient complains of an intense pain in the epigastrium usually radiating to the left. Nausea and vomiting are not outstanding symptoms. There is no shock. Tenderness to deep pressure in the epigastrium will be elicited. Fever, increased pulse rate and leukocytosis are moderate. It is hard to differentiate the condition from gallstone colic and sometimes from a penetrating peptic ulcer unless roentgen examinations are feasible. The absence of pain on deep inspiration with a finger under the right costal margin is helpful.

**Treatment**—If acute pancreatitis is suspected surgical treatment should be advised because of the possibility that hemorrhagic pancreatitis may supervene or an abscess may develop. The pancreas should be approached through the gastrohepatic omentum and the peritoneum over it incised transversely and widely. The area should be well drained with rubber covered gauze drains. The gallbladder should be removed. The common duct should be drained if jaundice is present or if the icterus index is high. If the pancreas seems large and hard in the head and jaundice is present some surgeons prefer cholecystogastrostomy or cholecystoduodenostomy. Choledochostomy is rarely indicated.

#### CHRONIC PANCREATITIS

**Etiology**—Chronic inflammation of the pancreas may represent simply moderate sclerosis with vague digestive disturbances and epigastric pain or a definite tumor mass with jaundice and cachexia simulating cancer.

The pancreas becomes of surgical interest when by reason of jaundice the life of the patient is threatened or when the etiology of the affection is believed to lie in some infection of the biliary tract which may be relieved by operation. Chronic pancreatitis may be concomitant with arteriosclerosis, syphilis or tuberculosis or may be associated as an indurative process with cirrhosis of the liver or the chronic nephritis of chronic alcoholism. A certain degree of chronic pancreatitis is associated with pancreatic calculi and carcinoma of the pancreas and with adherent deep ulcers of the stomach. Judd (1921) found that of a total number of 1290 patients with disease of the gallbladder and bile duct 347 (26.8 per cent) had associated pancreatitis. In attempting to diagnose chronic pancreatitis the symptomatology of all attacks of upper abdominal trouble which the patient may have had over a period of years must be considered.

**Symptoms.**—The symptomatology is grouped about pain, digestive disturbances and jaundice. Mostly the patients complain of attacks of dull boring pain in the epigastrium, sometimes referred to the right or left costal margin, back and shoulders. Rarely it is intense and has been mistaken for angina pectoris. Hinton believes that recurrent attacks of pain in the upper abdomen following cholecystectomy are sometimes due to an acute exacerbation of chronic pancreatitis lighted up by the operative procedure. Some of these patients undergo spontaneous recovery.

Sometimes there is merely discomfort after eating, especially of carbohydrates. *Flatulency* may occur some hours after taking food and may be preceded by epigastric discomfort. *Constipation* is more frequent than diarrhea and the latter never becomes chronic. Loss of weight and strength is frequent and naturally suggests malignant disease. A moderate anemia is usually present. *Jaundice* is not common as a visible symptom, but when the sclerosed head grips the common duct it may slowly progress to a deep greenish hue and simulate the jaundice of malignant disease. The intermittent character of jaundice due to a stone in the common duct must be considered. But even in pancreatitis the jaundice is rarely so tight as to cause the disappearance of bile from

the feces. Only rarely is the enlarged pancreas felt by palpation and then only in thin persons.

**Functional Tests.**—Theoretically, disease of the pancreas should so alter its function as to make a diagnosis of chronic interstitial pancreatitis relatively easy. But it is probable that unless the duct is blocked sufficient secretion enters the intestine to make the results of doubtful value in the early stages. Tests for pancreatic efficiency can include only examination of the feces for the presence of undigested protein, excessive quantities of fat or free starch. Estimation of the blood sugar and the icterus index may be helpful.

**Treatment.**—From the surgical standpoint the treatment of chronic pancreatitis is based on removal of chronic infection of the gallbladder or gallstones by cholecystectomy, drainage of the common duct or diversion of the bile by cholecystogastrostomy or cholecystoduodenostomy. In cases of chronic disease of the biliary tract the surgeon must decide whether or not there is concomitant enlargement of the pancreas and in such cases should drain the common duct for a few weeks. If there is any suspicion that carcinoma is present the gallbladder should be preserved and anastomosed to the stomach or duodenum. Medical treatment of any underlying factor is essential.

### PANCREATIC CALCULI

**Etiology.**—Because of the rarity of the condition and the difficulty of diagnosis pancreatic calculi are seldom recognized except at autopsy. The manner of their formation is probably similar to that of salivary calculi: a combination of stasis and infection. The common occurrence of gallstones and the rarity of pancreatic calculi are significant. They may lie in any part of the duct but are most common in the head of the pancreas. Complete obstruction of the duct results in atrophy and sclerosis of the parenchyma but the islets remain free from involvement. Retention cysts and abscesses are rare.

**Symptoms.**—The symptoms are not distinctive and are suggestive of chronic pancreatitis except that pain in the epigastrium is more marked and may radiate to the left

Jaundice and loss of weight have been observed. Positive functional disturbance of the pancreas is rarely noted in the cases reported with operation (Seeger 1925). As the substances composing the stone—calcium magnesium etc.—are radiopositive roentgen examination is important especially if the shadows are located behind the stomach in lateral views. The condition most frequently confused with pancreatic calculi is cholelithiasis. If the symptoms are those of stone colic and if gallstones are not found

gastrocolic omentum. All of these operations are rather difficult.

### PANCREATIC CYSTS

**Etiology and Types**—Cysts of the pancreas are comparatively rare and many of the reported cases classed as arising from the pancreas probably have arisen independent of this organ. Retention cysts have been ascribed variously to chronic pancreatitis, pancreatic calculi, gallstones or tumors. Proliferation cysts resemble the cystadenoma

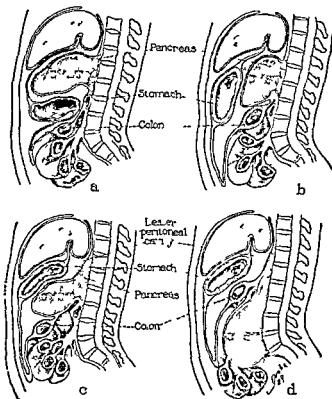


Fig 619—The relations of a cyst of the pancreas to the abdominal viscera. The most common site is exemplified in the next illustration. The situations shown respectively in a and b are the most frequent. The situation shown in c is very infrequent.\*

the surgeon should not neglect to palpate the pancreas. A feeling of crepitation is said to be suggestive.

**Treatment**—Calculi of any size and causing or probably causing obstruction should be removed by operation. The duct of Wirsung in the head of the pancreas may be reached by mobilizing the duodenum. The tail of the pancreas can be reached through the transverse mesocolon with proper protection of the middle colic artery. The body of the pancreas can be reached through an incision in the gastrohepatic or

nomia of the thyroid or ovary. Hydatid and dermoid cysts have been observed. Hemorrhagic cysts have been noted after trauma. Pseudocysts have no epithelial lining and lack the pancreatic ferment. They are collections of fluid in the region of the gland after inflammation or trauma. The various types are difficult to differentiate at operation.

The fluid content of the cyst is usually brown, probably from blood, but occasionally is clear. It is viscid and may contain

\* Judd, Mattson and Malmer: *Arch. Surg.* 62.



seem for advice and is often thought to be due to *cirrhotic jaundice* or to the unusual painless obstruction of the common duct by stone.

*Pain* is a symptom of importance and is usually colicky at first is epigastric and is often referred to *peptic ulcer* or *gallstones*. Later it becomes dull and constant and is referred to the back. Speed (1920) remarks that after an operation for relief of jaundice (such as *cholecystoduodenostomy*) the pain is relieved in most instances. This would bespeak the importance of dilatation of the gallbladder and ducts as a cause of the pain.

An epigastric tumor may be detected but great rigidity of the upper rectus muscle appears rather early and often obscures accurate palpation even when emaciation has produced a scaphoid abdomen falling sharply away from the costal margin. This is especially true in large-framed men with a broad deep upper abdomen. In other patients the mass can be felt but is apt to be a conglomerate affair composed of the growth in the pancreas lymph nodes and omentum. It does not move with respiration and the extension of the liver is usually fixed. A sign of great importance is the finding of a greatly distended gallbladder which moves with respiration. In the presence of jaundice this is significant of obstruction other than stone (Courvoisier's law). Stone in the common duct almost always is preceded or accompanied by chronic cholecystitis with thickening of the walls of the gallbladder which prevents dilatation.

The roentgen findings are not significant except that an increase in the size of the duodenal curve or a smooth defect in the outline of the stomach may suggest an adjacent tumor. Cholecystography is not important because failure of visualization of the gallbladder is usual in obstructive jaundice.

The most important lesion for differential diagnosis is chronic pancreatitis but the distinction cannot be made in the early stages of carcinoma. Even with the abdomen open surgeons have made the mistake of taking one for the other. The lesions of chronic pancreatitis and carcinoma of the pancreas sometimes resemble each other so closely that the differential diagnosis cannot be

made without removing a section of tissue for histologic examination. A previous history of infection of the gallbladder tract chronic and persistent would suggest the probability of pancreatitis. Courvoisier's law is an important point in diagnosis.

**Treatment**—As in carcinoma of most other parts of the body surgical removal offers the only chance for the patient. Only a few patients are seen early enough to offer hope for cure. However there should be few in whom exploratory operation is not justifiable partly because of doubtful diagnosis and partly because if the case is deemed hopeless a sidetracking operation may be done for the relief of jaundice after which the patient will live about a year. Cholecystogastrostomy is preferred and is feasible gastroenterostomy should be added as assisting the comfort of the patient.

In the event that the carcinoma is confined to the pancreas the surgeon should be prepared to perform a radical removal. Therefore the patient should be carefully prepared against the event of a severe operation.

Whipple (1938) has adequately pointed out that carcinoma of the head of the pancreas can be treated by radical resection. He has pointed out that ampullar carcinomas removed by the one stage procedure carried with them a higher mortality than those removed by the two stage procedure. Transduodenal removal with reimplantation of the common duct carries with it the danger of peritonitis and duodenal fistula. Local removal in either one or two stages carries a higher mortality rate than the radical two stage procedure with resection of the duodenum common duct and pancreas and closure of the pancreatic stump.

The original operation as developed by Whipple consisted of cholecystogastrostomy division and ligation of the common duct and gastrojejunostomy at the first stage. Three weeks later the greater portion of the duodenum common duct and pancreas were removed with closure of the pancreatic stump. This operation carried with it the danger of rapidly developing cholangitis and hepatitis by reason of the regurgitation of gastric contents into the biliary tree during forceful contractions of the stomach. Tests of pancreatic function after recovery indi-

ated that this patient was able to utilize 80 per cent of the fat, and only 15 per cent was recovered in the stool.

A further modification of this operation consisted in ligation of the common duct immediately below the cystic duct with an

the cholecystojejunostomy (Fig. 620). A gastrojejunostomy is performed at the second stage, followed by excision of the descending and second portion of the duodenum, the ampulla with the lower end of the common duct and a wedge-shaped por-

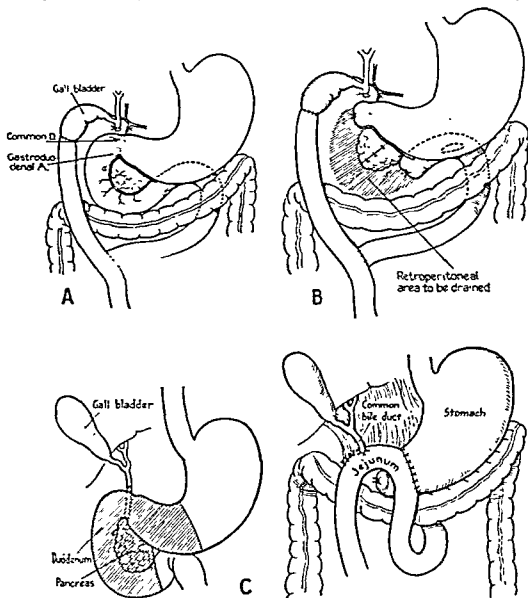


Fig. 620—1. First stage cholecystojejunostomy and end to side jejunojejunostomy, with or without gastroenterostomy \* B. Second stage duodenectomy with removal of part or all of the head of the pancreas. If gastroenterostomy has not been done in the first stage, it must be done in the second stage C. One stage radical duodenopancreatectomy, with anticolic gastrojejunostomy and implantation of the common duct into the jejunum.

anticolic cholecystojejunostomy on the Roux principle of anastomosing the distal end of the cut end of the jejunum to the fundus of the gallbladder, with end to side anastomosis of the functional cut end of the jejunum to the side of the jejunum 10 to 12 cm. below

tion of the head of the pancreas, ligation of the cut end of the pancreatic duct and closure of the stump (Fig. 620, B). This operation has been performed on 34 patients with minimal development of cholangitis.

\* Whipple: New England J. Med. 226.

## XXXII. THE SPLEEN

The spleen is one of the most interesting organs of the body, because it is involved in many abnormal conditions and also because there is still much uncertainty about its functions in health and about its role in many diseases

**Gross Anatomy**—The spleen is located in the left hypochondrium and is covered by the ninth tenth and eleventh ribs. Its average weight in the adult is slightly under 200 Gm. and it measures about 12 cm. in length 7 cm. in breadth and 4 cm. in thickness. The diaphragm stomach and left kidney are in contact with the surfaces of this organ

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**Histology**—Within the peritoneal investment (tunica serosa) the organ is enclosed by a capsule of connective and muscular tissue (tunica albuginea). From the inner surface of this layer, trabeculae spread throughout the spleen and this network constitutes the framework of the organ. Secondary processes divide the lobes into lobules and even smaller compartments or splenic units

The tissue of the spleen itself or pulp is composed mainly of reticulum cells and fibers and areas of lymphocytes. At frequent intervals the lymphocytes form compact groups known as malpighian bodies. The pulp also contains the cells normally found in the blood, since the escaping blood saturates the entire tissue

The branches of the splenic artery enter the hilum and accompanied by the veins run in the trabeculae. The arteries subdivide into arterioles or penicilli. A direct connection exists between the arterial capillaries and the venous sinuses. Kinsely has shown that the vascular system of the spleen is a closed one but that red blood cells can pass through stimulated or injured sinus walls. However, MacKenzie Whipple and Wintersteiner have stated recently that the system is really open and that the pulp space is the primary vascular unit. They think that when the capsule and trabeculae contract, the structurally "open" circulation becomes a functionally "closed" circuit

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**Physiology**—The chief functions of the spleen are (a) formation of lymphocytes and monocytes (b)

phagocytosis of bacteria inert particles, white blood cells and probably platelets (c) destruction of erythrocytes formation of bilirubin and thus storage of iron, and (d) storage of blood. Under excitement during exercise or after injection of adrenalin contraction of the spleen occurs and blood is forced into the circulation. This has been demonstrated in animals but not in man

Some other functions attributed to the spleen but not proved, are formation of purines production of a coagulating substance of the blood regulation of blood cholesterol production of an inhibitor of platelet formation and influencing of bone marrow function in general and production of immune substances

In spite of the fact that the spleen has apparently many functions its removal causes no permanent effects. Splenectomy in the normal mammal results in a mild temporary anemia an augmentation of reticulocytes an increase in the resistance of the red blood cells to hypotonic saline solution, cellular hyperplasia of the bone marrow and a marked rise in the platelet count. These changes are transitory since other organs of the body apparently take over the functions of the spleen. Despite suggestive animal experimentation, there is no evidence that removal of the spleen renders man less resistant to infection

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**Pathology**—In such conditions as Gaucher's disease, tuberculosis Hodgkin's disease and leukemia characteristic lesions are found by microscopic examination. But in most splenic disorders or ailments in which the spleen is involved no specific abnormalities are seen. Congestion, anemia, atrophy, hyperplasia, cysts, plasmia and fibrosis are the principal changes found and they appear in various combinations and proportions. In the case of the spleen therefore the pathologic findings in many conditions are not as important as functional and clinical changes. The lesions encountered will be described as each disorder affecting this organ is discussed

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**Classification**—It is impossible to classify abnormalities and diseases involving the spleen in a simple and logical manner because the etiology in many cases is not known and because there is no relationship between the various pathologic states. From a surgical viewpoint three divisions may be made as follows:

**A Conditions for which splenectomy is of decided value**

- 1 Traumatic lesions and non traumatic rupture
- 2 Anomalies of position and mechanical accidents (torsion and a movable spleen)
- 3 Spherocytic hemolytic jaundice
- 4 Thrombocytopenic purpura
- 5 Congestive splenomegaly splenic anemia Banti's syndrome
- 6 Schistosomiasis
- 7 Abscess (certain cases)
- 8 Cysts and hemangiomas
- 9 Neoplasms
- 10 Aneurysm of the splenic artery
- 11 Chronic neutropenia
- 12 Any condition in which a large spleen causes mechanical distress and in which splenectomy is not contra indicated

**B Conditions for which splenectomy is of possible value**

- 1 Gaucher's disease
- 2 Frittholistic anemia (Cooley von Jaksch)
- 3 Sickle cell anemia
- 4 Cirrhosis of the liver
- 5 Tuberculosis

**C Conditions for which splenectomy is of no value**

- 1 Syphilis
- 2 Amyloidosis
- 3 Kala azar
- 4 Malaria (tropical splenomegaly)
- 5 Polycythemia vera
- 6 Leukemia
- 7 Hodgkin's disease
- 8 Hemochromatosis
- 9 Anomalies
- 10 Other diseases

Various other diseases, some of which belong under group C of the foregoing classification merit mention for instance Nicomann Pick disease thrombophlebitis of the

splenic vein cysticercosis echinococcosis, infection Hand Schuller Christian disease Still's disease histoplasmosis agnogenic myeloid metaplasia and the Felty syndrome

In some diseases the spleen may be somewhat enlarged but these do not fall into surgical classification except for the problem of differential diagnosis. Illustrations of such conditions are subacute bacterial endocarditis infectious mononucleosis and pernicious anemia. Enlargement of the spleen may occur as a result of sulfonamide therapy.

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Reznikoff P. McGowan F. J. and Pool F. H. Surgery of the Spleen in Nelson's Loose Leaf Surgery N. Y. Thomas Nelson & Sons 1938 chap 7 p 343

**Diagnosis**—A correct diagnosis of disorders involving the spleen depends as in all diseases upon eliciting an adequate history performing a thorough physical examination and obtaining essential laboratory data. In many of the conditions under consideration special hematologic studies are necessary. These will be discussed under each disease.

Of paramount importance in the disorders in which splenomegaly occurs is the necessity for palpating this organ. Sometimes a very large spleen can be seen by inspection as it bulges from beneath the left costal margin into the abdomen. To be palpated a spleen must be at least twice normal in size. The patient must be relaxed and the examiner should begin palpating just above the brim of the pelvis working his way up to the costal margin in order not to miss a very large spleen. Flexion of the patient's thighs often increases relaxation of the abdominal wall. Breathing easily and deeply through the mouth and abdominal breathing if this can be performed without causing undue abdominal rigidity are desirable maneuvers. With the patient supine the examiner stands at the subject's right side places his left hand under the patient's left posterior lower costal region to support this area and uses the finger tips or the radial border of the index finger of the right hand parallel with the costal margin for palpation. If the patient can place his own left fist behind his back for support then both of the examiner's hands are free for palpation. An

other method which is of use is to turn the patient on his right side near the right edge of the bed thus permitting the spleen to fall toward the anterior abdominal wall the examiner kneels or is seated Of great importance in determining that the mass felt is the spleen is the definite palpation of a notch

Splenic puncture with aspiration of the contents has been advocated as a diagnostic procedure but there is grave danger of serious hemorrhage especially when the spleen is soft and acutely enlarged Of considerable value in diagnosis of splenomegaly is a flat plate of the abdomen with proper exposure If there is doubt in distinguishing between the spleen and the left kidney pnelography will be of assistance

### A CONDITIONS FOR WHICH SPLENECTOMY IS OF VALUE

**I Traumatic Lesions and Non Traumatic Rupture**—Subcutaneous injuries are much more common than open wounds and may be caused by direct or indirect violence Subcutaneous injuries may be divided into (a) lacerations of the parenchyma without rupture of the capsule (contusions) and (b) laceration of the capsule (ruptures)

Hemorrhage may be delayed after injury This occurs in 14 per cent of all cases of rupture Fifty per cent show signs in less than seven days and 95 per cent show signs in the second week after trauma However some patients bleed months after trauma (in one case two years afterward) This delay is due either to the insertion of bloody coagula or omentum in the splenic wound (tamponade) or to a large subcapsular hemorrhage which ultimately bursts the detached capsule

In contusions there may be pain tenderness local muscular rigidity and an increase in the size of the spleen Rupture of the capsule may occur with internal hemorrhage The pain in all injuries of the spleen is often referred to the left shoulder (Kehr's sign)

Rupture of the spleen gives rise to the symptoms of hemorrhage and shock Some indication of accumulation of blood within the peritoneal cavity may be obtained by dullness on percussion due to large blood clots in the splenic region with sh

ness in the right flank (Ballance's sign) The roentgenologic findings of increased density in the left upper quadrant of the abdomen obliteration of the splenic shadow elevation or tenting of the left diaphragm and displacement of the stomach toward the right side with evidence of free fluid between the loops of intestine offer an additional useful diagnostic aid (Webb's sign) The greater curvature of the stomach often presents a jagged serrated appearance and in massive hemorrhages reflex gastric dilatation occurs The blood changes are often suggestive in that hemorrhage gives an early and rapid increase in the number of leukocytes not accompanied by a relative fall in the hemoglobin value and the red cell count

Death may occur rapidly or the hemorrhage may be temporarily arrested only to recur The prognosis is bad if the patient is treated conservatively Splenectomy is the operation of choice yet adhesions may render splenectomy impossible in view of the condition of the patient In such cases suture or packing may be attempted for small tears In a large wound clamps or ligatures may be placed on the pedicle to control bleeding and the operation completed after shock has been controlled by transfusions

Stab wounds which are usually inflicted from above are often in the lower left portion of the thorax consequently the pleura lung and diaphragm are frequently involved But the wound may involve the left hypogastric or lumbar regions In gunshot wounds the bullet enters the abdomen more often than the thorax Therefore injuries of the gastrointestinal tract and kidneys predominate as associated lesions The prognosis is serious even in relatively slight wounds in which hemorrhage is

and symptoms may be slight. Replenishment is inadvisable because of the danger of infection. An independent incision and delivery of the spleen through the original wound with debridement of this wound is the operation of choice.

Spontaneous rupture occasionally occurs in a diseased spleen without obvious trauma, especially in cases of typhoid fever, malaria, pregnancy and puerperal infection. The symptoms are pain, tenderness and rigidity due to the rupture and to the irritation of the peritoneum by extravasated blood and are generalized because of the internal hemorrhage. Immediate splenectomy under local anesthesia alone or supplemented by light general anesthesia is indicated. Transfusions should be given as soon as the hemorrhage is arrested.

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**2 Anomalies of Position and Mechanical Accidents (Torsion and Movable Spleen).**—The large majority of cases of movable spleen are noted in women who have borne children. The significant feature is the relaxation of the abdominal walls. In most cases the mobile organ is abnormally large as a result of maternal or some other type of splenomegaly. The abnormal mobility usually develops gradually, the ligaments becoming elongated.

**Symptoms.**—Mobility may give rise to a variety of symptoms as the result of pressure or traction on adjacent structures. Traction on the stomach may cause epigastric pain, nausea and vomiting, compression of the intestines, obstipation, adhesions between the spleen and parietal peritoneum.

pressure on the uterus, uterine displacement and disturbance of menstruation. Rectal tenesmus may result from fixation in the pelvis.

If a movable spleen does not become fixed by adhesions, rotation on its pedicle or torsion may occur in which case violent symptoms may develop suggesting intestinal obstruction or a strangulated ovarian cyst.

**Treatment.**—Mobility which occasions no distress does not demand operation, yet the patient should be warned as to the dangers and kept under observation. If symptoms develop, operation is advisable and if torsion occurs, operation is imperative.

Although the immediate results of splenectomy are claimed to be favorable, the late results are uncertain. Splenectomy is the proper procedure since the spleen is often pathologic and since recurrence of torsion is usual. The operation is easy by reason of the elongated pedicle.

**3 Spherocytic, Hemolytic Jaundice (Acholic Jaundice).**—Spherocytic hemolytic jaundice is characterized by splenomegaly, acholic jaundice, anemia, a decreased resistance of red blood cells to hypotonic saline solution (fragility test), an increase of reticulocytes and a preponderance of microcytes which are spheroidal instead of biconcave in shape.

While a congenital and inherited type are generally described, doubt has been cast upon the existence of the latter. It is now known that adults may carry stigmas of the disease and show no signs and symptoms until some toxic or infectious episode precipitates an attack. Moreover, examination of the relatives of the patients with the 'acquired' type frequently reveals the typical traits of the condition.

The etiology is probably an inherited defect of the red blood cells which renders them small and globular so that they do not withstand the trauma of circulation. The role of the spleen in producing symptoms is probably due to the fact that the abnormal erythrocytes undergo increased damage in this organ.

Pathologically the spleen is enlarged and congested and has an increase of pigment as have also the liver, kidneys, bone marrow and lymph nodes. The sinuses of the spleen are empty and perisplenitis may be present.

sixty per cent of the patients have pigmented gallstones

The *symptoms and signs* of spherocytic jaundice vary but the most common evidence of this condition is jaundice. Splenomegaly may be the first manifestation of the disease and may cause the patient abdominal discomfort. In some cases anemia is the most striking finding. Often acute attacks characterize the disorder. These crises are manifested by upper abdominal pain, nausea, vomiting, fever and an increase of anemia and jaundice. These attacks frequently follow an infection, fatigue or a gastrointestinal upset. Chronic ulcers of the legs may complicate the condition.

The *laboratory findings* are characteristic in spherocytic jaundice. The anemia is normochromic or moderately hyperchromic. The cells are microcytic but their globular shape gives a higher volume index or volume thickness index than one usually obtains with small cells. This spherocytosis probably explains the decreased resistance to hypotonic saline solution (fragility) since these globular cells cannot swell as much as normal cells and therefore burst more readily. While normal red blood cells begin to hemolyze in 0.45 per cent saline solution and are completely laked in 0.3 per cent, the erythrocytes of these patients may begin to break up in 0.5 to 0.7 per cent and are often completely hemolyzed in 0.4 per cent. This constant destruction of red blood cells causes a marked increase in reticulocyte, as evidence of excessive bone marrow function. During crises even nucleated red blood cells may be found in the blood. The reticulocyte count may vary from 5 to 15 per cent. Other laboratory changes are an increased icterus index, a positive indirect van den Bergh reaction, bilirubinemia, urobilin in the urine and an increase of urobilin in the stool. In children skeletal changes similar to those found in erythroblastic anemia are seen.

The *diagnosis* of this condition is simple in most cases but some patients lack one or more of the characteristic findings—anemia, jaundice, splenomegaly, a change in the fragility curve or reticulocytosis. Moreover Dameshek, Schwartz and Singer and also Thompson emphasize that there are hemolytic anemias which are atypical and may require different therapy than does true

familial spherocytic jaundice although showing many similar features.

The *treatment* of typical spherocytic hemolytic jaundice is splenectomy. In no other condition are such brilliant results obtained. In Thompson's series of 30 patients only 1 failed to recover and at autopsy many accessory spleens were found. While it is desirable not to operate during a crisis, reports of successful operation during such an episode have been published. It must be remembered that these patients often react poorly to transfusions because of increased hemolysis and resulting anuria. Therefore preoperative transfusions should be avoided if possible. If cholecystectomy is necessary it should be postponed for a subsequent operation. After splenectomy relief of symptoms is often immediate and the jaundice disappears in a few weeks. The anemia improves rapidly and progressively and all evidences of hemolysis may be gone by the time the patient leaves his bed. The abnormal reaction of the erythrocytes to hypotonic saline solution, however, persists except in a very few cases in which a return to a normal state has been reported. Spherocytosis also continues. This indicates that while splenectomy results in disappearance of the symptoms and signs it has no effect upon the basic abnormality.

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4 **Thrombocytopenic Purpura.**—Thrombocytopenic purpura or Werlhof's disease is characterized by hemorrhages in the skin and subcutaneous tissues and from the mucous membranes of the nose, gums, gastrointestinal tract and endometrium. A marked reduction of platelets is found. The hemorrhagic areas may take the form of petechiae, ecchymoses or hematomas and the course of the illness may be acute, subacute, chronic or remittent.

twenty-four hours. In some cases after the postoperative increase of platelets there occurs a gradual fall to preoperative levels but in most of these patients hemorrhages do not reappear. Other methods of therapy such as frequent transfusions or irradiation of the spleen have also been advocated.

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**5 Congestive Splenomegaly (Splenic Anemia, Banti's Syndrome)**—Congestive splenomegaly is a term suggested by Thompson and his co-workers as best fitting the group of conditions previously called splenic anemia and Banti's syndrome. It is characterized by splenomegaly, anemia, leukopenia, and in many cases cirrhosis of the liver.

The *etiology* of the condition has been shown to be splenic vein hypertension caused by a variety of conditions. The most common reason for such hypertension is periportal cirrhosis of the liver of the Laennec type. Other causes of congestive splenomegaly given by Rousselot are schistosomiasis, malarial thrombosis of the splenic vein, cavernomatous transformation of the portal vein, and stenosis of the portal vein. Direct measurement of splenic vein pressure at operation compared to arm vein pressure showed a marked increase in cases of congestive splenomegaly as compared with that of controls. No other etiologic factors have had as good experimental and clinical substantiation as has the concept of increased splenic vein pressure. The disease occurs more frequently in males and is found during early adult life as a rule. A childhood type has been described.

*Pathologically* the large spleen has a rough surface due to perisplenitis and a thick capsule. The cut surface is resistant, tough and reddish gray. The follicles are small and reduced in number. Microscopic examination shows marked fibrosis.

The splenic and portal vessels are frequently sclerotic and the sinusoids are dilated and empty. Portal cirrhosis is found in many cases. Ascites, perihepatitis and varicosities of the veins of the lower part of the esophagus and of the stomach appear later in the disease.

The *symptoms and signs* vary with the stage of the disease. Enlargement of the spleen may be the first evidence of the affliction. This and anemia may exist for years. Occasionally hematemesis may be the initial indication of illness. Later hemorrhages in the skin and from the mucous membranes occur and usually indicate that cirrhosis of the liver is well established. The liver may be large at first but later shrinks. Finally ascites, loss of weight and some jaundice develop. In patients with a patent umbilical vein distended umbilical veins, a venous thrill and murmur may occur (Cruveilhier-Baumgarten syndrome).

The *laboratory findings* depend upon the particular stage of the disease. Early in the course a moderate normocytic anemia is present. In case of hemorrhage a microcytic hypochromic anemia results. Hepatic damage is frequently characterized by microcytic anemia. This however does not respond well to liver extract therapy. Leukopenia and thrombocytopenia are usually present. A slight increase in the resistance of the erythrocytes to hypotonic saline solution is often seen. The coagulation and bleeding times may be normal. The tourniquet test is positive and the icterus index somewhat elevated. The van den Bergh reaction is indirectly positive and in the later stages a positive direct reaction may be obtained. The urine contains urobilin and at times small quantities of bilirubin.

The *diagnosis* depends upon eliminating other causes of splenomegaly. As a rule splenomegaly with anemia, leukopenia and thrombocytopenia suggests congestive splenomegaly.

The *treatment* of this condition in its early stages is splenectomy. When cirrhosis



advanced the results are poor. Howells and Burg and Dulin have reviewed the results of splenectomy in their series of cases and while Howells does not believe that the operation prolongs life, Burg and Dulin feel it is the treatment of choice certainly in early cases. Ligation of the gastric coronary veins should be attempted if possible at the time of operation. The operative mortality varies from 7 to 10 per cent. Omentopexy may be tried to promote collateral circulation when cirrhosis and ascites are present. Transfusions, liver extract and vitamin B therapy are valuable adjuvants. Diuretics should be used for ascites and if they are unsuccessful paracentesis is indicated. Because of the danger of recurrence of hemorrhages, alcohol, condiments, excessive roughage and very hot foods should be avoided. Violent straining may also be dangerous. Hemorrhage in the presence of marked hepatic damage cannot be prevented by vitamin K administration because prothrombin cannot be manufactured.

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**6 Schistosomiasis.**—Patients suffering from infestation by blood fluke, are prone to enlargement of the liver and spleen (Egyptian and Columbian splenomegaly). The enlargement is due to cirrhosis and the splenic lesion is secondary. With the establishment of the hepatic cirrhosis, ascites, cachexia and gastrointestinal disturbances, the typical so-called Bant's disease of the Orient is recognized.

**7 Abscess.**—Although abscess of the spleen is an infrequent lesion, it occurs far more often than operative statistics indicate. As a complication of infectious diseases, it is frequently overlooked. The condition usu-

ally occurs as a metastatic abscess, occasionally as an infected hematoma and rarely as a direct extension of an adjacent suppurative process. Finally, there may be no demonstrable cause. Any infectious disease such as typhoid fever, puerperal sepsis, pyemia and localized suppurative processes may be the cause of a secondary splenic abscess. A characteristic feature of splenic abscesses is their marked tendency to form sequestra that is large necrotic masses of splenic tissue.

**Symptoms and Diagnosis.**—The clinical picture of splenic abscess is usually rather indefinite. It is not until the capsule is involved in the inflammatory process that the presence of the abscess manifests itself by pain due to perisplenitis. It often radiates to the left scapular region. Irregular chills and fever of an intermittent type are fairly constant. Enlargement of the spleen and tenderness on pressure may be noted. Abscesses in the upper segment often give rise to the symptoms of subphrenic abscess and are apt to be overlooked in consequence of the early involvement of the left pleura. Suppurative pleurisy may ensue and the original focus may be readily overlooked. The diaphragmatic movements on the left side are often absent as shown by fluoroscopy. Leukocytosis is usual but not constant but a marked increase of immature polymorphonuclear cells is always present. In doubtful cases exploratory puncture may be employed.

**Prognosis.**—In the absence of timely surgical intervention, the prognosis of abscess of the spleen is unfavorable. On the other hand, early operation is often followed by excellent results.

**Treatment.**—In most cases drainage of the abscess cavity has been performed but a considerable number of successful cases of splenectomy for splenic abscess have been reported. Schmeisser and Harris reported 29 cases of multiple necrosis of the spleen due to vascular thrombotic and infectious causes. Sulfonamide or penicillin therapy should be instituted.

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**8 Cysts and Hemangiomas**—Cysts of the spleen are rare but since they give rise to symptoms in a comparatively silent region of the abdomen—the left hypochondrium—a discussion of them is warranted. They may be divided for purposes of classification into the parasitic and non parasitic varieties.

McClure and Altemeier have classified cysts as follows:

- I True cysts—lined by specific secreting membrane
  - A Epithelial
    - 1 Dermoids
    - 2 Epidermoids
  - B Endothelial
    - 1 Lymphangioma
    - 2 Hemangioma
    - 3 Polycystic disease
    - 4 Some serous cysts
  - C Parasitic—lined by protoplasmic matrix containing numerous nuclei
    - 1 Hydatid cyst caused by echinococcus
- II False cysts—no specific secreting lining
  - A Hemorrhagic
  - B Serous
  - C Inflammatory
    - 1 Acute necrosis in infection
    - 2 Chronic tuberculosis
  - D Degenerative liquefaction of infarcted areas caused by embolism or arterial thrombosis

Non parasitic cysts of the spleen occur most often in women of the child bearing age. Contributing causes are splenic diseases and trauma. The wall of the cyst is lined either with fibrous tissue or with cells of mesothelial or endothelial origin.

Parasitic cysts of the spleen occur in about 2 per cent of cases of hydatid disease. They are large and multilocular and are lined with the echinococcus membrane, the inner layer of which contains larval scolices. In addition to the general symptomatology of a mass in the left hypochondrium of diagnostic import, the complement fixation test, a precipitin test and microscopic examination of the cystic fluid for hooklets are important.

Pressure symptoms arise in cases of either variety of cysts. Pain in the left hypochondrium is often associated with vague indigestion, weakness and anemia. Swelling in the left hypochondrium with extrinsic dis-

tortion of the splenic flexure visible in the roentgenogram must bring a diagnosis of splenic cyst into consideration. A bruit heard over the left hypochondrium is the classical sign of a hemangioma.

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**9 Neoplasms**—New growths of the spleen are uncommon. Secondary metastases are rare because of the spleen's contractility and its paucity of lymphatics according to Warren and Davis but Herbut and Gabriel report 23 cases. Tumors of the spleen may be classified as follows:

- (a) Benign fibroma, lymphoma, hemangioma, lymphangioma, chondroma, osteoma
- (b) Malignant angiosarcoma, lymphosarcoma, reticulum cell sarcoma

Goldberg has published a review on primary splenic neoplasms and recently Hausmann and Gaarde summarized the literature dealing with malignant neoplasms. Sweet and Warren described a benign tumor which they called a splenoma or hamartoma of the spleen.

The rapid growth of a hard mass in the left hypochondrium should suggest a neoplasm, especially if a nodular surface is felt. Early splenectomy is the only hope for a cure. At operation the pedicle should be ligated before any manipulation is done so as to prevent displacement of tumor cells into the circulation. When splenectomy is impossible, irradiation may be employed.

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### 10 Aneurysm of the Splenic Artery —

This is a rare condition but has been diagnosed preoperatively. Since Crisp's report in 1847 less than 100 cases have been recorded. This condition has been reported as a complication of pregnancy. Rupture frequently occurs. Arteriosclerosis, neoplasm of the pancreas, embolism, syphilis or trauma has occasionally been found to be the cause of aneurysm, but often no reason for the lesion is revealed at autopsy. The patient complains of vague distress in the left upper portion of the abdomen. Pulsation or a faint bruit is rarely noted. In performing splenectomy it is advisable to ligate the splenic vessels proximal to the aneurysm as a preliminary step.

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### 11 Primary Splenic Neutropenia —

Wiseman and Doan have described a chronic febrile condition characterized by neutropenia and splenomegaly which is cured by splenectomy.

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## B CONDITIONS FOR WHICH SPLENECTOMY IS OF POSSIBLE VALUE

### 1 Gaucher's Disease —

Gaucher's disease is a chronic familial and sometimes congenital disturbance of lipid metabolism in which certain cells of specific significance and morphology appear in the spleen, liver, lymph nodes and bone marrow. These so-called Gaucher cells have their origin through the deposition of a cerebroside-keratin in the reticulum and histiocytic cells of these organs. They appear in no other disease.

The cells are very large and have psyknotic

and sometimes multiple eccentric nuclei. The cytoplasm is made up of a fibrillar network which gives it a wrinkled appearance. The kerosin containing cytoplasm does not stain with the fat stains and is not doubly refractile. Masses of Gaucher cells account for the white speckling of the spleen and hepatic substance as well as the nodular infiltration of lymph nodes and bone marrow. The latter along with the increased porosity and thinning of the cortex without cortical infiltration gives a recognizable roentgenologic entity.

Clinically Gaucher's disease shows progressive and marked splenomegaly with out ascites and lesser hepatic enlargement and a visible lymphadenopathy. Hypochromic anemia and leukopenia are constant findings in the peripheral blood. Thrombocytopenia and the hemorrhagic diathesis are frequently present late in the course of the disease. Of variable occurrence are brownish yellow pigmentations of the exposed skin, pterygium like thickening of the ocular conjunctiva, spastic tremors and convulsions, and unique changes in the bones in persons constitutionally predisposed to them. The onset of the disease is most frequent in persons under the age of forty, the maximum incidence being under five years of age and between the ages of twenty five and thirty five. The course may be rapid with marked splenomegaly and hepatomegaly or it may run for twenty years or more. The most frequent termination is intercurrent infection. Tuberculosis is not infrequently responsible.

The diagnosis can be established frequently by splenic or marrow puncture for identification of the specific cells, biopsy of a peripheral lymph node or roentgenologic examination of the bones.

The treatment of Gaucher's disease is symptomatic inasmuch as knowledge of its cause is still incomplete. Splenectomy obviously holds no hope of cure. A large burdensome spleen, thrombocytopenia and the hemorrhagic diathesis may be considered as indications for palliative removal of the spleen. In spite of the high mortality reported by some authorities and the chronicity of the disease in some cases without operation it is generally considered that splenectomized patients have a longer and more comfortable life.

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2. Erythroblastic Anemia (Cooley, von Jaksch).—In 1889 von Jaksch described a chronic anemia of childhood in which there developed pronounced changes in the shape and size of the red blood cells, a large hard spleen, some hepatic swelling and leukocytosis. Many childhood anemias classified as this condition have subsequently found a place in hemolytic icterus, splenic anemia, leukemia, etc. There remains a group, however, different from the rest but having essential features in common which Cooley definitely identified and called erythroblastic anemia. Von Jaksch's description failed to include quite a number of its characteristics.
- This is a rare congenital and sometimes familial disease of children of Mediterranean races. Therefore Whipple and Bradford call it thalassemia (Mediterranean anemia). The onset is in the first few years of life, the course is chronic and progressive and the termination is usually fatal. The fundamental disorder is apparently one of abnormal hematopoiesis. The most common characteristics of the disease have been fully described by Bats, Blackfan and Diamond and may be enumerated as follows: enlargement of the malar and cranial bones imparting to the child a mongolian facies; progressive enlargement of the abdomen because of marked splenomegaly and a lesser hepatomegaly; pallor; subicteric tint or jaundice of the skin; mild generalized enlargement of the peripheral lymph nodes and generalized skeletal changes visible in the roentgenograms and comprising cortical thinning, increase in the width of the bones, increased porosity and thickening of the medullary trabeculations. The changes in the bone marrow consist of marked hyperplasia of the erythroblastic elements and to a much less degree hyperplasia of the myeloid elements so that the marrow is almost identical with that in pernicious anemia during a relapse. The peripheral blood shows a tremendous increase in young nucleated red cells (the number often reaching many thousands), a moderate anemia of low color index, anisocytosis, poikilocytosis and achromia of the red cells and a constant leukocytosis, the count averaging 20,000 with a predominance of the myeloid series and a few young forms.
- Abnormal hemolysis is reflected in a positive indirect van den Bergh reaction usually a mildly elevated icteric index and an increased urobilinogen output in the stool and urine, although there is no increased red cell fragility to hypotonic saline solution. The spleen is enlarged up to seven times its normal size and microscopically shows extramedullary hematopoiesis of the erythroblastic series and a lesser myeloid response. The liver exhibits like changes to a much less extent.
- One of the distinguishing features of the disease is the normoblastic reaction to splenectomy, the count frequently exceeding 100,000. This number gradually falls, but the essential blood picture remains unaltered. Thus, as in many splenomegalies, splenectomy is of little curative value, but as a palliative measure it relieves the growing child of the harrowing burden of progressive splenomegaly and there is evidence that this may actually retard the progress of the disease and prolong life. There is also an adult type of this Mediterranean disease which is familial and which is characterized by a low hemoglobin and relatively high red blood cell count, sometimes polycythemia, stippling, target cells and splenomegaly.

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**3 Sickle Cell Anemia**—Sickle cell anemia is an inherited disease found chiefly in Negroes but has also been reported in other races. Many individuals show sickle anemia but only about 1 in 40 actually suffers from anemia. In early life the spleen is large but becomes fibrotic and soon atrophies. The chief symptoms are weakness, dyspnea and ulcers on the legs. In children changes occur in the skull similar to those seen in erythroblastosis. Complications due to cerebral vascular thrombosis are not uncommon. Abdominal crises, joint pains, attacks of jaundice and fever are frequent. The main laboratory findings are anemia, usually normocytic in type, an increased icterus index and serum bilirubin, a positive indirect van den Bergh reaction, urobilinuria, reticulocytosis, occasionally nucleated red blood cells in the peripheral blood, leukocytosis with an increase of immature polymorphonuclears and thrombocytosis. Most important of all in the diagnosis is the presence of sickling best demonstrated by moist preparations in decreased oxygen tension.

There is considerable difference of opinion about the efficacy of splenectomy in sickle cell anemia. Operation during a crisis should be avoided.

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**4 Cirrhosis of the Liver**—In cirrhosis of the liver, enlargement of the spleen is constant, this being due to increased splenic venous pressure. When the spleen enlarges markedly, the condition is essentially congestive splenomegaly, which has been described previously. Although splenectomy cannot affect the liver directly, removal of the spleen reduces the amount of blood in the portal circulation and reduces the load upon the liver. If regeneration of hepatic tissue is possible with the aid of vitamin therapy, splenectomy from a theoretical viewpoint at least might be logical. How-

ever, such a procedure would be of value only in the early stages of cirrhosis. Omentopexy to provide compensatory circulation in the presence of ascites is not performed frequently now.

**5 Tuberculosis**—Tuberculosis of spleen may be primary or secondary. The latter type is relatively frequent and is not amenable to surgical treatment. Winteritz collected reports of 21 cases of marked involvement of the spleen. The most common features of the condition are pain and enlargement of the spleen with the symptoms of general malaise. Occasionally the symptoms are those of an acute infection. The blood picture may resemble that found in congestive splenomegaly or thrombocytopenic purpura. Healed tuberculosis of the spleen has not only been found at autopsy but calcified areas have been demonstrated by x-ray. If no tuberculosis is evident elsewhere, splenectomy is indicated in tuberculosis of the spleen. Several cases have been reported with successful results.

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#### C. CONDITIONS FOR WHICH SPLENECTOMY IS OF NO VALUE

There are many splenomegalic conditions which merit mention principally because they must be differentiated by the surgeon from disorders for which splenectomy is of

value These diseases will be described briefly

1 **Syphilis**—Splenomegaly occurs usually in the tertiary stage of syphilis and is characterized by fibrosis or gummas In the florid secondary stage the spleen may be palpable As a rule antiluetic therapy is the treatment of choice However when the large spleen causes symptoms for mechanical reasons splenectomy may be considered This should be followed by vigorous specific therapy Occasionally splenomegaly with gastric hemorrhage is encountered In such cases splenectomy is desirable

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2 **Amyloidosis**—Amyloidosis affects the spleen more commonly than it does any other organ The amyloid material is a protein which takes a walnut or mahogany brown color when stained with iodine The condition is secondary to chronic infection elsewhere in the body such as tuberculosis or osteomyelitis The congo red test is used for diagnosing amyloidosis and depends upon the fact that amyloid in the tissues takes up the dye and retains it for long periods

3 **Kala Azar**—Kala azar is caused by a protozoan *Leishmania donovani* which is found in the spleen liver and blood and in the cells of the reticuloendothelial system The condition occurs mostly in eastern Asia The chief features of the disease are irregular fever weakness dark pigmentation of the skin enlargement of the spleen and liver anemia leukopenia sometimes granulocytopenia and thrombocytopenia Pentavalent antimony compounds are used for treatment Splenectomy is not indicated

4 **Malaria (Tropical Splenomegaly)**—Enlargement of the spleen is but one of the evidences of chronic malaria The disease is not located exclusively in the spleen nor is that organ an incubator for the malarial parasite Therefore the removal of the chronic malarial spleen will not bring about a cure of the infection On the contrary it may stir into activity an infection which has apparently been cured Recently malaria has become common among drug addicts be-

cause of the transference of the plasmodia from an infected patient by the use of an unsterilized needle and syringe To the surgeon malarial spleens are of importance because rupture may occur after slight trauma or even spontaneously

5 **Polycythaemia Vera**—Polycythemia is found most frequently in adult males and is characterized by a marked increase in the red blood cell count (varying from 8 000 000 to 11 000 000) cyanosis and splenomegaly Secondary polycythemia may occur in congenital heart disease pulmonary arterio sclerosis (Auer's disease), thrombosis of the splenic vein and in many other conditions A hypertensive type and a congenital form also occur In polycythemia vera a marked increase in the formation of red blood cells by the bone marrow is the cause of the polyglobulism Phlebotomy, x-ray therapy acetylphenylhydrazine and Fowler's solution are the therapeutic measures used

#### REFERENCE

Reznikoff P Polycythemia, in Nelson's Loose-Leaf Medicine New York, Thomas Nelson & Sons 1941

6 **Leukemia**—Splenic enlargement is found in all types of leukemia The disease occurs at all ages and is characterized by widespread disorderly proliferation of leukocytes with an apparent arrest of maturation In typical cases the white blood cell count is high sometimes running up to several hundred thousand Anemia is often present In myelocytic leukemia the bone marrow is hyperplastic Lymphocytic leukemia affects the lymphoid tissue and monocytic leukemia involves the reticuloendothelial system The average length of life in chronic leukemia is about three years Acute leukemia may prove fatal in a few weeks or months and patients suffering from this type of disease may never show any appreciable enlargement of the spleen Therapy is usually some type of irradiation Fowler's solution may be used in myelogenous leukemia

#### REFERENCE

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7 **Hodgkin's Disease**—Hodgkin's disease is a chronic granulomatous process involving the lymphoid tissue The earliest

change in the lymph nodes is a hyperplasia of lymphoid cells. Later the lymph nodes lose their characteristic structure and the tissue is filled with closely packed cells among which plasma cells, epithelioid cells, eosinophils and Dörrth Reed Sternberg cells are found. Fibrosis occurs later. The spleen is enlarged in the majority of cases and occasionally is very large. Splenic Hodgkin's disease may be characterized by a remittent fever; this is called the Pel-Ebstein type. The etiologic factor is unknown. A few instances have been reported in which the splenic enlargement apparently was the only clinical evidence of the disease. Splenectomy would be indicated in primary splenic Hodgkin's disease if the diagnosis could be made.

#### REFERENCE

- Jaeger, H. Jr. Report on Medical Progress Hodgkin's Disease and Allied Disorders. New England J. Med. 240:6, 1929.

8. Hemochromatosis.—Hemochromatosis is characterized by pigmentation of the skin and viscera, diabetes and hepatosplenomegaly. A diffuse deposit of hemosiderin is found in the organs and lymph nodes. The spleen is fibrotic and the liver cirrhotic.

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- Flaum, G., and Steck, C. H., Jr. Hemochromatosis. Report of a Case with Necropsy and Analysis of the Liver. Arch. Int. Med. 63:133, 1929.

9. Anomalies.—Complete absence of the spleen occurs rarely but is compatible with health and longevity. Microplenia, multiple or accessory spleens (usually situated near the hilum), lobulation, congenital hernia of the spleen through the diaphragm and transposition of the spleen to the right side in situs transversus are anomalies which have been described in the literature.

10. Other Diseases.—Many diseases are accompanied by some splenic enlargement. In disorders like Niemann-Pick's disease and Hünd-Schüller-Christian's disease (two conditions which are similar but show distinct differences from Gaucher's splenomegaly) and in Lederer's anemia (an affliction characterized by fever and hemolytic anemia) the spleen may show considerable increase in size. In infection, in congestive heart failure and sometimes in pernicious anemia the spleen may be palpable. This is especially

true in subacute bacterial endocarditis. In infectious mononucleosis often presents splenic enlargement.

Infarction of the spleen is not infrequent. It may occur in infectious conditions giving rise to a septic infarct terminating in an abscess. Local pain is usually present especially if perisplenitis develops.

Stillé's disease is seen in children and the picture is one of chronic infectious arthritis with hyperplasia of the lymph nodes, enlargement of the spleen and liver, normocytic anemia and frequently leukopenia. Idiopathic syndrome is a splenomegaly condition in adults resembling Stillé's disease but recently the existence of such a condition has been questioned by Talkov, Bauer and Short.

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#### OPERATIVE PROCEDURE

Surgical diseases of the spleen are usually best treated by splenectomy, since its affections commonly involve the entire organ or if local as in injuries, cysts or tumors the attempt to substitute lesser procedures is attended by greater danger than removal of the entire organ. In addition splenectomy has been advocated and performed in cases of total or subtotal pancreatectomy, of total gastrectomy and of partial gastrectomy by the thoracic route to secure better exposure. The operation may be of great simplicity or of the greatest difficulty. Hemorrhage is the chief danger. Injury of the pancreas or the adjacent stomach has often occurred and can be obviated only by adequate exposure.

and care. It is wise always to have a donor present for immediate transfusion if necessary. Any incision may be used which gives adequate exposure but it is essential that complete control of the operative field is assured before the spleen itself is attacked.

The chief difficulties are usually due to the presence of highly vascular adhesions and to the development of exceedingly large thin walled veins which are easily ruptured and bleed copiously thus obscuring the field. When these complicating conditions are absent as in the ordinary case of traumatic rupture with a normal spleen or in

doubly ligating and dividing all available vessels before attempting to mobilize or dislocate the spleen. If the pedicle can be secured before the spleen is stripped from its high attachments the operation is rendered much safer. In certain cases however, it is simpler to separate the spleen posteriorly and superiorly and introduce a large moist hot pack into the vault of the diaphragm applying pressure to control the venous oozing while the pedicle is isolated and secured. The spleen in this procedure is rolled inward (turned turtle) exposing the posterior aspect of the pedicle. It should never be at



Fig. 621—Ligation of splenic pedicle.\*

the case of a wandering spleen or in the earliest stages of splenomegaly it is a simple matter to secure the pedicle as the first procedure thereby insuring control of any hemorrhage that may occur. Under these conditions after the bloodless peritoneal attachments of the gastrosplenic omentum and lienorenal ligament have been severed the pedicle may be grasped at once with crushing clamps and ligated en masse or it may be compressed by a rubber-covered clamp and the vessels ligated separately. When adhesions and large thin walled veins are present it is essential to proceed cautiously

tempted until all available vessels at the lower pole have been secured.

After removal of the spleen the cavity should be carefully inspected and if possible all oozing surfaces or bleeding vessels that cannot be separately clamped secured by oversewing with catgut ligature the so-called snaking suture. In some cases it is necessary though never desirable to leave a pack in place covering the oozing surface. Occasionally inaccessible vessels must be clamped and the clamps left in place for two or three days before removal.

\* Balfour Surg. Gynec. & Obst. 93



If an accessory spleen or spleens are present, these should be removed in case of diffuse splenic disease. If ascites is present, the fluid should be completely removed before the spleen is treated. No drainage is necessary unless tamponade for bleeding is indicated.

**Other Operative Procedures**—An ectopic or wandering spleen may be treated by splenopexy if the organ is small and apparently normal. In this operation the posterior parietal peritoneum is incised transversely just below the diaphragm and a pocket made by stripping the peritoneum from its posterior attachments. Into this the lower pole of the spleen is inserted and secured by ligature. It is usually better to perform splenectomy for this condition. Splenorraphy is occasionally feasible to check hemorrhage from small traumatic ruptures. Ligation of the splenic artery has been carried out in a few instances in splenomegaly but is not recommended, because of the danger of necrosis of the spleen and the uncertainty of the results on splenic disease. Occasionally resection of the spleen may be feasible for small accessible cysts and benign tumors. It is, however, rarely indicated, and the dif-

ficulty of controlling bleeding by suture of the spleen will always make its adoption of doubtful propriety. Splenotomy, or incision of the spleen, for abscess is advisable in those cases in which the spleen has attached itself by inflammatory adhesions to the abdominal wall.

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## XXXIII HERNIA

### GENERAL CONSIDERATIONS

**Definition**—The protrusion of any viscus from the cavity in which it normally belongs through either a natural or an acquired opening is called a hernia or in older parlance a rupture.

**General Considerations**—Abdominal hernias are named according to the location of the hernial ring, thus inguinal, femoral, umbilical, epigastric, lateral, ventral, lumbar, sciatic, obturator, perineal and pudendal. The viscera involved are in order of frequency, omentum, intestine and urinary bladder, although in rare cases other abdominal or pelvic organs may be encountered. All these are external hernias.

The internal hernias are usually due to some congenital anomaly in development and include hernia into the fossa of Treitz, the foramen of Winslow, the intersigmoid fossa and the pericecal fossa. Diagnosis is occasionally made by x-ray before operation but usually during operation for intestinal obstruction. Diaphragmatic hernia occurs either through congenital defects or through rents due to trauma and penetrating wounds.

**Relative Frequency**—According to the statistics on a large series of cases reported from different clinics, ventral hernia constitutes 89 per cent of all abdominal hernias, incisional or postoperative hernia, 8 per cent, femoral hernia, 4.5 per cent, umbilical hernia, 3.8 per cent, epigastric hernia, 0.7 per cent, and all other types together less than 1 per cent.

The inguinal, the femoral and the umbilical hernias occur through natural apertures provided for the emergence of important blood vessels and other structures and similarly the sciatic, the obturator and others of the less common hernias may be accounted for under the theory that hernia occurs through a fascial defect or hiatus provided for the passage of blood vessels.

Mosel *et al.* accepts the Lippoma theory of Cloquet as the best explanation for epigastric hernia and of hernia in the semilunar line also called lateral ventral or Scirrhous hernia. The outgrowth or protrusion of a peritoneal lipoma through the fascial hiatus alongside some small vessel may later drag a funnel of peritoneum after it forming a true hernia sac. Owing to the tilting forward of the pelvis accompanying the erect posture of man, the lower abdominal wall is

subjected to strains and pressures which are lacking in quadrupeds.

In the inguinal canal as in no other hernial region embryonic development not only has provided a defect in the peritoneum but actually forms a potential hernial sac of peritoneum as the processus vaginalis peritonei is dragged to the bottom of the scrotum in the male or as the canal of Nuck is carried out with the round ligament into the vaginal canal of the female. Although this vaginal process normally becomes sealed off shortly before or after birth, Sir Arthur Keith states that in 50 per cent of male infants it remains open up to the fourth month. The number of males who go through life with a patent funicular process which means a potential hernial sac is stated by Russell to be 10 per cent and by Sachs to be 20 per cent. By no means all of these susceptible persons ever have a hernia for this only when omentum or intestine has protruded into the patent process, that a hernia can be said to exist. Keith has shown that the conjoined internal oblique and transversalis muscles under reflex nervous mechanism act against the fixed *Ligamentum inguinale* in the manner of an inguinal shutter which serves to close the internal inguinal ring against internal strain.

**Factors Involved in the Etiology of Oblique Inguinal Hernia**—These factors are (1) patency of the vaginal process due to congenital defect in closure, (2) a sudden increase of intra-abdominal pressure as in coughing, straining or lifting, (3) a sudden strain which catches the inguinal shutter off its guard. Especially in the stooping position the conjoined muscles and Poupart's ligament are relaxed. Under these conditions omentum or intestine may be forced through the internal ring and a hernia may develop. This explanation is not accepted by all writers and there are some eminent surgeons who assert that hernia is not an acute surgical entity but in reality a progressive disease. They claim that a hernia never results from a single isolated strain because it is inconceivable that an elongated or pear-shaped sac could develop instantaneously from the parietal peritoneum but that repeated impulses over a long period would be required to hammer the peritoneum into this shape. This strong argument seems less tenable since more recent studies show that 10 per cent of adult males have patent peritoneal processes already formed into a sac

Other surgeons claim that every oblique hernia is congenital implying that the potential sac is in itself a hernia. Others state that the sudden appearance of a hernia must be accompanied by evidence of the rupture of tissues. No such evidence is found even in early operation on an ordinary oblique hernia nor is it necessary to adduce this evidence if the sacular theory of oblique hernia is accepted.

#### Degrees of Involvement in Hernia—

**Reducible** hernia disappears when the patient lies down or when light pressure is applied.

**Irreducible** hernia by reason of adhesions or bulk of contents is not uncommon in very large and old hernias. An irreducible hernia may become inflamed when the omental content has been subjected to trauma by a truss or taxis with or without infection from the intestinal tract. Occasionally fecal impaction in a large irreducible hernia in an aged person causes the hernia to become choked or obstructed. The term incarcerated hernia is of vague significance being used by some as synonymous with irreducible and by certain German writers as including also strangulated hernia.

**Strangulated Hernia**—A hernia is said to be strangulated when by reason of sudden accession of contents and tightness of the ring or neck interference with the circulation of blood develops. If a loop of bowel is present symptoms of intestinal obstruction appear and the intestine rapidly becomes gangrenous. According to statistics on hospital admissions over 25 per cent of femoral hernias and 15 per cent of umbilical hernias are strangulated whereas only 9 to 3 per cent of inguinal hernias are found to be strangulated. Most of the strangulated inguinal hernias are oblique because direct hernias seldom become irreducible. Whether a hernia is merely temporarily irreducible obstructed or inflamed may be of academic interest but the only safe rule must be that any hernia which suddenly becomes larger irreducible tense and tender accompanied by local and abdominal pain followed by nausea or vomiting is to be considered a strangulated hernia and demands immediate operation. Venous congestion and edema occur serum collects and the intestine becomes dull red. Hemorrhagic inflammation

follows with emigration of bacteria from the intestine and bloody serum is produced and the intestine becomes purple. The serosa loses its gloss and is rough with fibrin. Gangrene seldom occurs before twenty-four hours although it has been reported as early as from four to six hours perhaps due to harmful taxis or to faulty history. When gangrenous the intestine is black or gray lusterless flabby non-resilient and granular and the sac contains bloody or purulent foul smelling fluid.

**Treatment of Strangulated Hernia**—Taxis should be avoided. The patient should be treated for shock and dehydration with saline or Hartman's solution given as intravenous infusions and external heat. Gastric lavage is instituted so as to rid the stomach of toxic fluids and to prevent drowning under general anesthesia. Local or spinal anesthesia is preferable to a general anesthesia in advanced cases. Operation should aim at the quickest and least shock giving relief of the obstruction. After the sac has been exposed it is carefully opened. The constricted area is located with a finger in the sac and is divided by dissection from without inward not by blind cutting from within out with the old fashioned herniotome or bistoury.

Cases of doubtful viability require experience and sound judgment. Even though the bowel is blue purple or black if it retains its luster and elasticity and shows any return toward normal color after the application of warm saline pads for from five to ten minutes it may be considered viable. At the Mayo Clinic the anesthetist momentarily administers pure oxygen which causes an immediate improvement in the color of the bowel if its circulation is intact. If resection is absolutely indicated the operation is carried out through a laparotomy incision and is wisely accompanied by an enterostomy at a higher level for temporary drainage of the paralytic ileus which persists above the point of previous obstruction. Many lives have been saved by simply leaving the loop of bowel outside the abdomen wrapped in saline gauze and incising it for drainage or in less advanced cases watching it for twenty-four hours when its circulation may have so far recovered that it may be replaced within the abdominal cavity and the hernia

repaired. Immediate resection is attended by a very high mortality.

SEWARD ERDMAN

## INGUINAL HERNIA

Examinations of drafted men during the first World War showed that over 2 per cent had inguinal hernias. Four fifths of all hernias are inguinal. Over 90 per cent of hernias in males and about half of the hernias in females are inguinal. The two great classes of inguinal hernia are (a) *oblique or indirect inguinal* and (b) *direct inguinal hernia*. A third class is the *direct indirect hernia* with its *saddle bag or pantaloon sac* which straddles the deep epigastric vessels and presents the combination of a direct sac together with an indirect sac, both clinically and surgically this type is merely another form of direct hernia and must be treated as such. When inguinal hernias are bilateral they are practically always of the same type on the two sides.

An omental hernia or epiplocele contains only omentum. If a loop of bowel is included the hernia is called an *enterocele*. When only a portion of the wall of the bowel is caught in the hernia ring it is called a *partial enterocele* or *Richters* or *Littre's* hernia. This latter occurs rarely in oblique hernia but not infrequently in femoral hernia and may progress to gangrene and perforation without complete obstruction of the lumen of the bowel. Hernia of the urinary bladder is frequently associated with direct inguinal hernia and large oblique inguinal hernias whereas sliding hernia of the sigmoid flexure or cecum is of comparatively rare occurrence and is always associated with oblique hernia.

**Oblique Inguinal Hernia**—In an inguinal hernia if the neck of the sac issues laterally to the deep epigastric vessels through the internal abdominal ring and follows intimately the course of the spermatic cord it is called an oblique or indirect inguinal hernia.

Oblique inguinal hernia is ten times more frequent in the male than in the female obviously owing to the descent of the testis, and as this descent occurs later on the right side there is a preponderance of right sided

oblique hernias. Oblique hernia becomes bilateral sooner or later in 25 per cent of cases. Keith states that 44 per cent of male infants have a hernia in the first year of life but Bull found that fully two thirds of these disappear either spontaneously or with the aid of a truss. Few new hernias develop during childhood but from adolescence up to the age of thirty during the period of most strenuous exercise and physical strain the vast majority of ordinary oblique hernias make their appearance and come to operation.

**Etiology**—There is almost unanimous agreement today that defective closure of the processus vaginalis is the predisposing factor and that the exciting factors of suddenly increased intra-abdominal pressure and failure of Keith's inguinal shutter permit the actual development of a hernia, i. e. the protrusion of a viscus.

**Anatomy**—For the detailed anatomy of the inguinal region reference must be made to textbooks of anatomy and only certain points which are of importance in the surgery of hernia will be mentioned here. The spermatic cord represents the conjunct of its two major components the vas deferens and the spermatic vessels each of which approaches the internal abdominal ring from a different direction. The femoral sac or its predecessor the patent foramen process protrudes through the internal ring between and slightly above these structures as if the cord elements furnished a ski for the sac which then glides into the inguinal canal. The inguinal canal lies in front of or superficial to the vas and the vessels. Therefore it will be seen that an oblique sac is intimately associated with the structures of the cord and contained within the same sheath (i. e. consisting of the infundibular fascia the cremasteric fascia and the intercolumnar fascia) as each of these tissues is encountered by the testis at the internal ring in the inguinal canal and at the external ring respectively.

Three arteries and three nerves are encountered in the inguinal canal, namely the important spermatic artery, a branch of the aorta, the small artery of the vas from the internal iliac and the cremasteric from the deep epigastric; the genital branch of the genitofemoral nerve which runs beneath the cord into the scrotum; the inguinal branch of the ilioinguinal nerve placed superficial to the cremaster and emerging through the external ring; hence subject to injury at operation; and lastly the hypogastric branch of the iliohypogastric placed still higher on the surface of the internal oblique muscle.

The lower border of the internal oblique muscle arches across the internal ring and runs almost horizontally mesally until it reaches the rectus sheath in the semilunar line together with the lower border of the transversalis directly beneath it forms the "true muscle" border which is drawn down and sutured to

Poupart's ligament in practically all hernioplasties. The lowest fibers of insertion near the rectus sheath are described by anatomists as the "conjoined tendon" but Blake and later Bloodgood and Ziemann have shown that this structure is so frequently attenuated narrowed or obliterated that its use in hernioplasty is seldom practicable therefore it is the "true muscle" border which is used and is called the conjoined muscle. The cremaster muscle is in reality merely the lowest fibers of the internal oblique muscle which originally lay across the face of the internal ring and which was stretched and thinned out as it was pushed ahead of the testicle in its descent. The deep epigastric artery arises from the external iliac near the middle of Poupart's ligament and runs upward in the properitoneal tissues directed toward the umbilicus. It forms the dividing line between the internal ring and Hesselbach's triangle.

An hernia occurring mesial to this artery is called direct whereas an oblique hernia emerges through the internal ring which is lateral to the deep epigastric.

The fibers of the external oblique aponeurosis run downward and inward toward their insertion in the pubic bone but diverge as they approach the pubis forming the pillars of the external abdominal ring. Ordinarily this ring will not admit the fingertip although about 3 per cent of male adults have a larger or relaxed ring which predisposes to the later occurrence of direct hernia.

**Varieties of Oblique Inguinal Hernia**—1 Ordinary oblique inguinal hernia formerly called the adult or the acquired type, is in no essential different from the hernia into the funicular process. It may reach down to the tunica vaginalis but does not communicate with it.

2 *Hernia into the tunica vaginalis* is preferable to the term congenital hernia, formerly used to describe complete patency of the processus vaginalis permitting the hernial contents to enter the tunica vaginalis in the scrotum.

3 *Encysted hernia and infantile hernia* Moscovitz regards as practically identical. When the vaginal process is sealed off in the inguinal canal but open below this level the oblique sac may either invaginate into the tunica vaginalis or pass down behind it thus either two or three layers of peritoneum must be incised before the hernial content is exposed.

4 *Oblique inguinal hernia in the female* occurs when the canal of Nuck remains patent after it has been dragged out into the inguinal canal by the round ligament. At operation the delicate sac is more difficult of dissection from the round ligament than from the cord in the male but this dissection should always be attempted. Some surgeons include the round ligament with the neck of the sac in the transfixion ligation and excise the distal portion others suture the stump to the margin of the internal ring in order to support the uterus and to prevent retraction of the cut ligament away from the sac ligature.

5 *Hernia with non descended testis* is very common as a part of the arrested development.

6 *Interstitial hernia* is a rare and interesting accompaniment of maldescent of the testis where the hernial sac unable to pass out of the inguinal canal spreads out between the muscle planes of the abdominal wall

in an upward direction toward the umbilicus. Usually the sac lies between the aponeurosis and the internal oblique but may occur in the properitoneal space.

**Direct Inguinal Hernia**—A direct inguinal hernia bulges through the floor of Hesselbach's triangle formed by the floor of the deep epigastric artery, Poupart's ligament and the border of rectus muscle either separating or pushing the transversalis fascia ahead of it. Etiologically, anatomically and surgically it differs essentially from an oblique hernia.

Practically unknown in the female and in children, it occurs almost entirely in male adults from twenty five to fifty years of age. Some of the factors which weaken the defenses of the floor of Hesselbach's triangle are an enlarged external ring which is found almost exclusively in the male at tenation or obliteration of the conjoined tendon in abnormally high position of the true muscle border according to Polya and degenerative changes in the musculature. The lipoma theory of Cloquet and Moschcowitz has been mentioned. Direct indirect hernia with its "saddlebag" sac straddling the epigastric vessels occurs in about one third of the cases of direct hernia. Its characteristics and surgical treatment are essentially those of direct hernia. Care must be exercised not to overlook and fail to remove one or the other of the component sacs.

**Differential Diagnosis**—In males oblique hernia occurs in 75 per cent of inguinal hernias and direct in 25 per cent. In females only 2 per cent are direct. Oblique hernia occurs from infancy up to thirty years and direct hernia usually after thirty. The oblique hernia is oval or pear shaped descends obliquely on coughing frequently is scrotal and sometimes is irreducible. After reduction of an oblique hernia, finger pressure over the internal ring will prevent its reappearance whereas this is not true of direct hernias. The direct hernia is globular protrudes straight out through the external ring hardly ever enters the scrotum and is practically always reducible. The external ring is not enlarged in oblique hernia until the hernia is complete but is always enlarged in direct hernia. In oblique hernia the posterior wall of the canal feels firm when the finger is inserted in direct hernia the finger passes directly backward through the de-

fective posterior wall. The epigastric artery fails to assist in the diagnosis because it is seldom palpable by external examination.

**Treatment of Inguinal Hernia.**—*Mechanical treatment* by trusses and bandages may be curative in infancy but such cure lacks permanency. A truss is an excellent palliative measure if disease advanced age or repeated failure of surgical cure contraindicates operation.

**Injection Methods.**—For a discussion of injection treatment see the paragraphs at the end of this chapter.

**Surgical Treatment of Inguinal Hernia.**—*Hernioplasty*, the plastic repair of the her-

nial defect, is (Poupart's) ever results in firm union. The verdict is that satisfactory union of muscle to fascia and fascia to fascia is largely dependent on the careful removal of all intervening areolar tissue and this important fact must be remembered by the surgeon.

**Modern Operations for Hernia.**—All types of operation for hernia fulfill the underlying principles but differ in the plastic reconstruction.

1 *Transplantation of the Cord, the Bassini Operation.*—This operation initiated the era of modern hernioplasty and was described almost simultaneously by Marey in

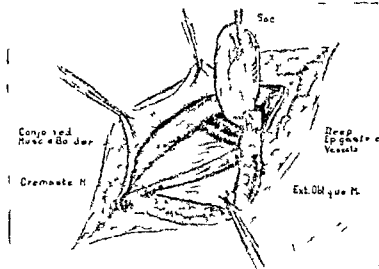


Fig. 222.—Oiliq hernia. The neck of the sac is dissected away from the cord; it is lateral to the deep epigastric vessels and is ready for opening high transfixion ligation and excision.

nial defect has supplanted herniotomy as the method for the relief of strangulated hernia.

Three general principles underlie practically all inguinal hernioplasties: (a) complete dissection of the inguinal canal; (b) high ligation and excision of the sac; and (c) plastic reconstruction of the inguinal canal. Exceptions to these principles are found in the operations of LaRocque, Blandine and Leon Sutton, who use a laparotomy incision and remove the sac intra-abdominally, a method yielding good results in their hands but which has not gained any widespread adoption. Much discussion has arisen and much animal experimentation has been pursued to determine whether or not muscle

America and Bassini in Italy. It consists of the following steps: (1) a skin incision well above and parallel with Poupart's ligament; (2) a splitting incision of the aponeurosis outward from the upper margin of the external ring; (3) a splitting of the cremaster to expose the oblique sac overlying the cord structures; (4) careful dissection of the sac away from the cord well up to the internal ring; and (5) high transfixion ligation of the sac and excision. (6) The plastic repair consists in depressing the cremaster fibers and suturing the true muscle border of the conjoined muscles down to the sliding border of Poupart's ligament while the cord is elevated out of the wound. The cord is thus transplanted somewhat outward and super-

cially, is now dropped back on the surface of the internal oblique and the aponeurosis is closed in front of the cord. If used for direct hernia the rectus sheath or the rectus muscle itself may be sutured to Poupart's ligament. Maclellan has advised transplantation of the cord to the femoral canal by separating Poupart's ligament and later resuturing it over the cord.

2. *Non transplantation of the cord* is typified by the Ferguson or Coley Ferguson operation and by the Johns Hopkins operation. The Bassini steps 1 through 5 are followed but for step 6 the cord is replaced beneath the cremaster; the conjoint muscles are su-

hernoplasty proceeds (a) with separate suture of the transversalis fascia and (b) suture of the conjoint muscle to Poupart's ligament (c) with the cord still elevated. The upper or mesial leaf of aponeurosis is sutured to Poupart's ligament and the lower leaf is overlapped upward and sutured to the surface of the upper leaf. The cord then emerges through the aponeurosis opposite the internal ring and runs down toward the scrotum subcutaneously. The author excises the cremaster muscle to permit better closure of the inner angle and Burdick has in selected cases resorted to division of the cord which he says does not al-

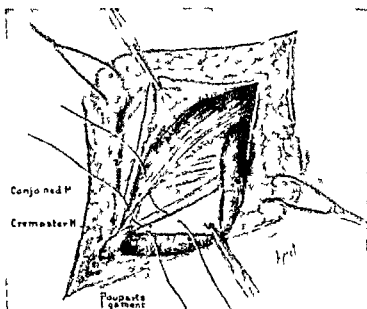


Fig. 623.—Bassini operation with transplantation of the cord. Showing suture of the conjoint muscle to the sheath, behind of Poupart's ligaments in front of the cremaster.

tured to Poupart's ligament in front of the cord and the aponeurosis is closed.

3. *Extra-aponeurotic transplantation* was first practiced by Halsted and later modified by Andrews, Woolsey, Stetten, Downes, and Friedman. It is indicated in direct hernia and in old large obliques also in most recurrent hernias. This operation makes use of a strong fascia to fascia overlap of the aponeurotic flaps to fortify Hesselbach's triangle and its weak inner angle. In direct hernia the sac bulges through the posterior wall of the canal above the level of the cord and is never intimately related to the structures of the cord. After the cremaster is split the transversalis fascia must be opened to expose the sac. After excision of the sac the

walls cause atrophy of the testicle. Estes describes an interesting modification of the fascia to fascia operation which seems especially adapted for direct hernia. He excises the cremaster and uses a flap from the rectus sheath permitting double fascia to fascia pherion to fortify the weak inner angle of Hesselbach's triangle.

*Indications*.—The Bassini operation has so long been the classic operation and so widely adopted that many surgeons employ it for every type of inguinal hernia. However, there are certain definite contraindications to its use: (a) In infants and young children it shortens the cord and elevates the testicle; hence it is objectionable. (b) In operations for non-descent, (c) the Bassini

transplantation operation does not adequately strengthen the inner part of Hesselbach's triangle, the area of weakness responsible for direct hernia, as is proved by the

The Ferguson non-transplantation is the operation of choice for infants and young children and in non-descent of the testis and is undoubtedly adequate for many other ob-

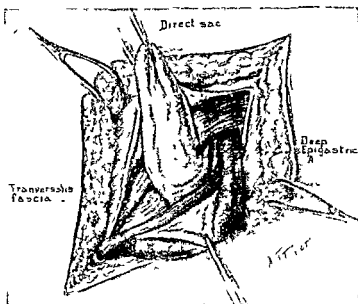


Fig 624.—Direct hernia. The sac protrudes through the transversalis fascia mesial to the epigastrics

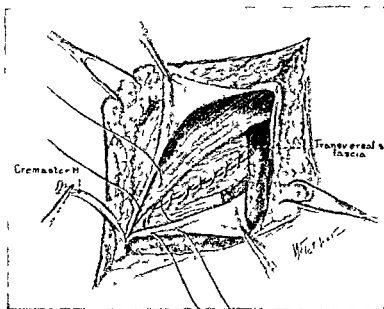


Fig 625.—Operation for direct hernia showing the importance of suture of the transversalis fascia before suturing the conjoined muscles to Poupart's ligament. In difficult or recurrent cases excision of the cremaster muscle allows better closure of the inner angle. The distal stump of the cremaster is later tacked on the surface of the aponeurosis to support the testis.

most dependable follow-up reports, which show a recurrence rate of from 15 to 30 per cent for direct hernias treated by either the Bassini or the Ferguson operation.

lique hernias when small and without muscular or fascial defect.

For the efficient treatment of direct and direct-indirect hernia, the writer firmly be-



leaves that additional measures must be taken to fortify the weak posterior wall of the canal and to close the innermost angle where inner angle recurrence of direct hernia are so prone to occur hence the extra aponeurotic transplantation operation with excision of the cremaster is recommended for direct hernia or the Gallie fascial suture method in exceptional cases. A small direct hernia may be merely replaced.

**Suture Material**—Chromic catgut is most commonly used and has stood the test of time. The use of silk alone for ligations and sutures combined with meticulous handling of tissues has greatly reduced the

lies autogenous fascia. Koontz has recommended preserved ox fascia. Alloy steel wire sutures are advocated by Babcock. The silk technic method has gained many advocates recently and I believe silk is by far the best suture material for the average hernia. Recently Alton Ochsner, Gage, Harold Loss, Donald Guthrie and others have adopted the use of plain white sewing cotton as the most satisfactory form of ligature and suture superior to silk and much cheaper. As for the late results of the use of Gallie fascial sutures, Burdick's experience at the Hospital for Ruptured and Crippled in New York has been very discouraging.

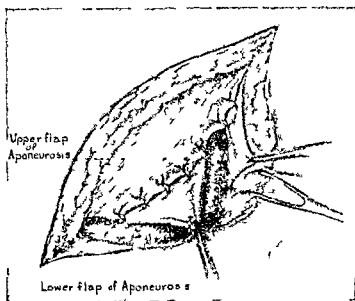


Fig. 62C.—Extra aponeurotic transplant. The upper leaf of the aponeurosis is sutured to Poupart's ligament after the conjoint muscle has been sutured to the shelving border. The inner angle is now well closed and covered. The lower flap is overlapped upward and sutured to the surface of the upper flap. The cord runs subcutaneously.

recurrence rate at the Presbyterian Hospital, New York (W. B. Parsons). The living fascial suture method of Gallie described in 1921 may be used for difficult inguinal and other hernias. Many years before Gallie, McArthur used a narrow fascial strip from the upper flap of the aponeurosis, but the generous supply of autogenous fascial sutures obtainable from the fascia lata of the thigh by Gallie's method greatly enlarges the usefulness of such sutures. In the Gallie operation for inguinal hernia, a special needle and technic are used to weave the fascial sutures across the hernial defect in basket work fashion, forming in reality a new fascial plane of defense. Instead of Gal-

**Operative Accidents**—Injury to the intestine while the sac is being opened, injury to the bladder in direct hernia and injury to the vas and to the spermatic vessels must be guarded against. Injury to the nerves may give rise to testicular neuralgia. The femoral vein should not be injured during the suturing of Poupart's ligament.

**Postoperative Treatment**—Rest in bed in an ordinary case of oblique hernia should be continued for eleven days, although some surgeons say eight and still others fourteen days. In cases of direct and of recurrent hernia, the time should be at least fifteen days, and many surgeons insist on three weeks.

Eight to ten weeks before the patient returns to work is usually allowed by labor boards but three months should elapse before any heavy work is undertaken.

**Complications**—Swellings of the scrotum usually temporary are the result of trauma and dissection at operation rather than lack of support of the testicle after operation they include hematomas thrombosed veins epididymo-orchitis and hydrocele. A pronounced epididymo orchitis is prone to result in atrophy of the testis later.

**Recurrence**—Failure to remove both components of a saddle bag sac failure to wipe away all areolar tissue too tight sutures which cut through tissues improper choice of operation too early return of the patient to work deep infection of the wound and failure to fortify the inner angle are factors in causing a recurrence. Failure to excise the cremaster is the cause of many inner angle recurrences. From a number of the largest and best surgical clinics follow up reports based on actual examinations show from 3 to 7 per cent of recurrences after operation for oblique hernia and from 15 to 30 per cent after operations for direct hernia. Probably throughout the hospitals of the country the actual rate is even higher. Over half of the recurrences are apparent within six months nearly 80 per cent have recurred within one year and about 90 per cent before the lapse of two years. Reliable follow up reports must be based only on those patients who have been followed for two years and have actually been re-examined.

**Injection Treatment.**—Since Ignatz Mayer of Detroit in 1927 reintroduced treatment of hernia with injections of irritants and claimed 98 per cent cures this method has gained numerous adherents in various parts of the country. Prolonged night and day wearing of a truss is an essential feature. Many types of hernia are unsuitable for injection the most favorable is the small oblique sac in a young person in a small percentage of these cases obliteration of the sac may result in a cure. The early tissue reaction causes a marked thickening which may temporarily hold back the hernia or so mark its presence that a cure is claimed for a few months.

Biopsies performed by Kelly on injected

animals at ten day intervals showed that the early fibroblastic tissue had practically disappeared in one hundred days and had been largely absorbed within fifty days. Dobson in 1940 confirmed Kelly's experiments. Coley of the Hospital for Ruptured and Crippled New York found 81.03 per cent relapses after injection treatment. The Council of the American Medical Association stated in *The Journal* on Aug 17 1940.

After due consideration of a second hospital survey [the Council] reaffirms its previous opinion that the Injection Treatment may not be recognized for general use. Universal employment of the method is to be deplored.

From reliable statistics the injection method offers a prospect of cure to one patient out of eight.

SEWARD ELDMAN

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middle one for the vein and an inner channel usually filled with fatty areolar tissue which is known as the femoral canal. It is through this canal that a femoral hernia passes to enter the thigh. The upper boundary of the femoral canal is the femoral ring which is bounded anteriorly by Poupart's ligament medially by Gimbernat's ligament laterally by the femoral vein and posteriorly by Cooper's fascia which covers the superior surface of the horizontal ramus of the os pubis. The femoral ring is separated from the internal abdominal ring by the deep epigastric artery which lies close to the upper and outer margin of the femoral ring. When as happens in about one third of the subjects the obturator artery springs from the deep epigastric artery it crosses the upper and inner portions of the femoral ring and consequently may be injured at operation if the ring must be divided. Serious hemorrhage may then ensue. The underlying density of the aponeurotic and bony structures that form the femoral ring favors early strangulation. This is also intensified by the abrupt angle made by the sac as it bulges for-

less the sac contains irreducible omentum is seldom severe. The uncomplicated case usually presents as the only symptom a dragging sensation in the groin.

**Physical Examination.**—On inspection a fullness or even a distinct globular swelling may be seen but if the patient is obese or if the hernia is small there is often no external evidence of its presence. Palpation reveals a globular mass situated just beneath Poupart's ligament and external to the spine of the pubis. Owing to the fact that the sac is frequently surrounded by considerable preperitoneal fat, the mass often fails to disappear completely when attempts at reduction are made. This does not therefore indicate the presence of irreducible omentum. A true impulse on coughing is not nearly as constant a finding as in inguinal hernia because the neck of the sac is frequently very narrow. When strangulation is present a cramp like pain, nausea and vomiting are noted while distention may be present in varying degree. Auscultation may reveal audible peristalsis.

**Diagnosis.**—It should be borne in mind that the sac in some cases of femoral hernia tends to pass up over Poupart's ligament to lie above it on the surface of the external oblique and in such instances may be easily mistaken for an inguinal hernia. If the relation to the pubic spine is carefully sought for however it will generally be possible to avoid this error for an inguinal hernia is always internal to the pubic spine and when small is above it while the neck of the femoral sac is always external to the spine. The question can be settled with certainty, however, if the finger can be introduced into the external inguinal ring and if it is found to be empty while the swelling below persists.

ward upon the thigh after escaping from the saphenous opening. These factors tend to favor constriction and congestion of the contents of the sac. The coverings of a femoral hernia are peritoneum, preperitoneal fat (crural septum), femoral sheath, embryonic fascia, superficial fascia and skin.

**Symptoms.**—The patient may be quite unaware of the presence of a femoral hernia and the cramp like pain, nausea and vomiting of obstruction due to strangulation may be the first symptoms noted. It is therefore essential to include a careful palpation of the femoral area in the examination of every patient with an acute abdominal condition. Often however, there is complaint of a painful swelling in the groin which may or may not diminish or disappear when the patient is in the recumbent position (Fig. 628). The degree of pain is variable however and un-

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**Varix of the saphenous vein** is a condition which may closely simulate femoral hernia. It should always be borne in mind during the examination of a suspected femoral hernia. Both conditions present a swelling in the same area which tends to disappear when the patient lies down and to reappear when he coughs or strains. The distinction must be made by the character of the sensation imparted to the finger during coughing. In femoral hernia this sensation is the peculiar crepitation which one learns to associate with hernias and which has been termed an impulse. In saphenous varix the sensation is best termed a thrill. This peculiar tactile sensation may easily



Fig. 628.—Bilateral femoral hernia.

Even in cases in which the contents of the sac can be completely reduced it is difficult to control the hernia completely by the most carefully fitted truss. While the bowel may be kept from entering the sac a small strand of omentum often becomes extruded and in time becomes adherent and irreducible. For this reason the writer always advises operative treatment in cases of femoral hernia in which there is no definite contraindication. In cases in which it is not deemed advisable to operate a truss should be worn to prevent the hernia from increasing in size or from becoming strangulated. When operation is refused or definitely contraindicated small reducible femoral hernias offer the best prospect of being held by a truss. Of these a cross-body frame truss with a small water-filled pad is probably the most effective and comfortable.

**Operative Treatment**—Two methods of approach have been recognized as standard procedures for the cure of femoral hernia: the femoral approach through Scarpa's triangle and the inguinal approach through or above the inguinal canal. While opinions differ as to which method is superior for the average case each method has its definite field of usefulness. The high or inguinal operation is particularly to be urged when strangulation is present. It is also essential when dealing with a hernia which has a large relaxed femoral ring. For by this method reduction and inspection of the strangulated contents are facilitated and resection if required is more easily and rapidly performed and where the ring is large and relaxed suturing Poupart's ligament to Cooper's ligament effectually closes the ring at its entrance instead of lower down.

Many other procedures some of them quite ingenious have been proposed but have been discarded among these may be mentioned Roux metal staple to fasten Poupart's ligament to the pubic bone, Fascia peritoneum bone and muscle have been advocated in autoplasmic procedures by Silzer, Mikulicz and Edmund Andrews but for exceptional cases only.

In the average case of a small uncomplicated femoral hernia however the low approach through Scarpa's triangle gives excellent results and has the advantage of being

**Treatment of Femoral Hernia**—As in hernias in general the two forms of treatment to be considered are the mechanical or truss method and the surgical or so called radical cure. This latter term originated about fifty years ago when hernias were seldom operated on and treatment was almost entirely carried out by trusses. In the years that have followed the improvement in surgical technique in general and in hernia surgery in particular has placed the operative method firmly in the preferred position. This is especially true of femoral hernia because a truss virtually never effects a cure and is a more cumbersome and less effective palliative measure than is the case in inguinal hernia. Since the pad must press on the region of Scarpa's triangle it tends to be displaced with every movement. Compression of the adjacent femoral vein must be avoided. Moreover since in most cases the femoral sac cannot be completely reduced owing to the surrounding preperitoneal fat the pressure of the truss aggravates the condition and in consequence definitely contraindicates

more easily and quickly performed. This operation bears the same relation to femoral hernia that Bassini's does to inguinal hernia. It is recommended for general use in preference to the inguinal operation by Burdick, W. B. Coley, Seward, Erdman and Watson.

the neck of the sac the writer prefers one placed obliquely lying over Poupart's ligament. The latter facilitates the introduction of the sutures for closing the femoral ring, and should in error in diagnosis have been made the exposure of the inguinal canal is

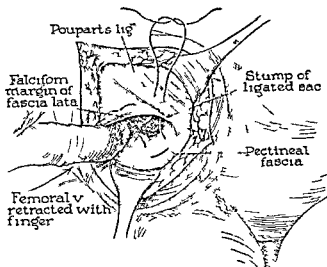


Fig. 629—Femoral or low operation showing the stump of the sac which has been transfixed and ligated at the neck and a purse string suture inserted so that when tied will close the femoral opening.

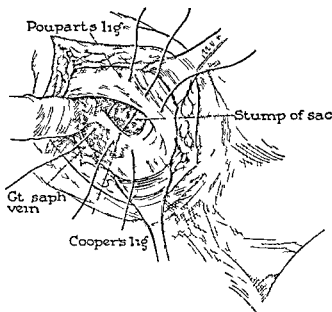


Fig. 630—Closure using one layer of interrupted sutures that approximate Cooper's ligament and the transversalis fascia to Poupart's ligament.

**Femoral Approach**—This operation with various modifications was advocated by Berger, Bassini, Cushing, W. B. Coley, Marcy and others. While the incision may be made vertical with its mid portion over

readily accomplished. The incision 3 inches (7.5 cm.) in length terminating at the pubic spine divides the skin and deep layer of the superficial fascia and exposes the sac and preperitoneal fat. These are freed from

adjacent tissues, and the neck of the sac is identified. Gentle traction and careful dissection with scissors about the femoral ring make it possible to separate the adhesions

the femoral ring can be secured, and upon this rests the success of the operation.

Next the sac is opened, great care being taken because of the possibility that though

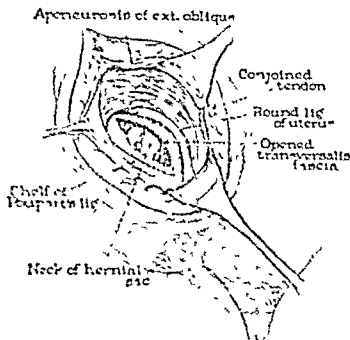


Fig. 631.—Lateral operation for femoral hernia showing the relationship of the neck of the femoral sac to the inguinal canal and adjacent structures.

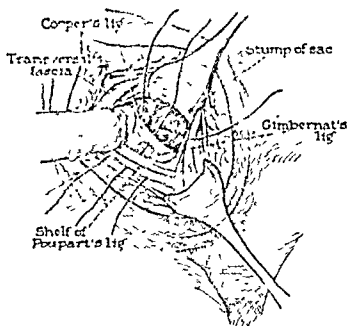


Fig. 632.—The closure of the femoral ring from above by suture of Cooper's ligament to Poupart's ligament after disposure of the sac following high ligation of the neck.\*

and pull down the neck of the sac. This is the important step, for if good exposure is not obtained, neither high ligation of the neck of the sac nor satisfactory closure of

the sac seems to be empty, yet the bladder may occupy the inner wall and may be damaged. Omentum may be present in the sac.

\* Watson, *Hernia*, C. V. Mosby Co., Publishers.

and must be reduced if non adherent or ligated and excised. The sac together with its surrounding peritoneal fat is then ligated either separately or together (Fig 629). This is done by passing a transfixion suture well above the original neck of the sac. After it has been ligated and the sac has been excised the stump must retract well up beyond the femoral ring. This step doubtless cures the majority of small uncomplicated femoral hernias in which the neck is narrow and the femoral ring not greatly relaxed. The fascia overlying the pectineus muscle is then exposed and cleared of all areolar tissue. The sutures which are of silk or of medium chromic catgut are introduced so as to close the femoral ring. The first suture is placed innermost while a blunt retractor protects the femoral vein. It traverses Poupart's ligament and then picks up a portion of the pectineus muscle and fascia directly below the ligament the needle being directed inward away from the vein. It then passes upward to enter Poupart's ligament again about  $\frac{3}{8}$  inch mesial to the beginning (Fig 630). This mattress suture is held taut and if it is insufficient to close the ring adequately a second or even a third suture may be placed before any are tied. The use of a small curved needle is important for otherwise the muscle and fascia directly beneath Poupart's ligament cannot be picked up and the femoral canal will thus be closed not at its base but at its apex. This theoretical objection to the operation is raised by proponents of the other method.

*Inguinal Approach*—This method was first advocated by Annandale in 1876 although priority has been erroneously given to Lotheissen who described the operation in 1898. Gordon (1900) and Moschowitz (1905) introduced modifications of the method and popularized it. During the past few decades many writers have urged that it be given preference over the femoral approach regarding it as the ideal procedure for closing the canal at the highest possible point. The incision is made as for an inguinal hernia but prolonged a trifle lower over the pubis. The external oblique aponeurosis is divided exposing the inguinal canal. The spermatic cord or the round ligament is retracted and the internal oblique and trans-

versalis muscles also. The floor of the inguinal canal is Hesslebach's triangle composed of a layer of transversalis fascia is then opened along the line of the incision and with adequate retraction the neck of the femoral sac is exposed proximal to the point where it passes into the femoral canal. Cowell has termed this the suprascapular portion of peritoneum (Fig 631). Traction on the sac if empty usually succeeds in inverting it up through the ring where it is then ligated at the point of origin. If there are irreducible contents without strangulation gentle traction combined with pressure over the femoral region below will often accomplish reduction. In some instances however it may be necessary to prolong the incision expose the femoral sac and open it below. Adherent omentum can then be ligated and excised and the sac then with drawn upward through the ring. The technique when strangulation exists will be discussed under strangulated femoral hernia.

After the neck of the sac has been ligated and the distal portion has been excised the femoral ring is closed from within by interrupted sutures. With the femoral vein carefully retracted the outermost suture is passed between Poupart's ligament and that portion of the pectineal fascia known as Cooper's ligament which covers the ramus of the pubis (Fig 632). Successive sutures are similarly placed the innermost one including Gimbernat's ligament. The transversalis fascia is then closed and the inguinal canal repaired as in an operation for inguinal hernia but without transplantation of the cord.

There is a possibility that a direct inguinal hernia may follow the inguinal operation for femoral hernia and special care should be taken in the closure of the transversalis fascia. Dickson in fact sutures the transversalis fascia to Cooper's ligament separately and then closes the femoral canal by suturing Poupart's ligament to Cooper's ligament. This modification of the inguinal method seems to minimize the danger of the development of a direct hernia subsequently due to damage to or weakness of the transversalis fascia.

*Suture Material*—Progressive increase in the use of non absorbable materials such as cotton or silk in repair of hernia has been

noted in many clinics. During the past sixteen years of 211 operations done at Hospital for Ruptured and Crippled in 93 catgut and kangaroo tendon was used and in 102 fascial sutures were used but these were done prior to 1915. Since 1915 there have been 108 operations in all of which cotton, silk or nylon was used.

**Treatment of Strangulated Femoral Hernia—Taxis**—Taxis and operation are the only methods of treatment available. Taxis is a dangerous procedure attended by grave risk. It should be reserved for the rare cases in which operation would be extremely hazardous: as in cases of senility and severe cardiovascular and pulmonary disease. Among the dangers entailed by taxis may be mentioned the risk of rupture or serious damage to the intestine, reduction of gangrenous intestine into the abdominal cavity, rupture of the sac near the neck and reduction en masse with failure to relieve the symptoms of obstruction.

Taxis is absolutely contraindicated if symptoms of strangulation have been present for more than one or two hours or if there are already present evidences of inflammation of the overlying skin or marked sensitiveness.

In the writer's opinion taxis is rarely justified and is usually to be condemned. A safer procedure is to place the patient in a warm bath and administer morphine hypodermically. If spontaneous reduction does not take place within a half hour operation should be undertaken at once.

**Operation**—Whenever the diagnosis is clear the inguinal approach should be selected. If when the peritoneum is opened the contents of the sac can be pulled up out of the ring the operation is not difficult and the sac can be removed after the neck has been transfixed. Closure of the femoral ring is then effected as has been previously described. If reduction is impossible by traction it is best to prolong the incision to expose the femoral region and the fundus of the sac which is then opened. Bimanual combined taxis and traction may then permit of reduction though manual dilation of the ring or in extreme cases division of it is sometimes necessary. In dividing the ring Gimbernat's ligament is nicked an aberrant obturator artery being cautiously

avoided. Poupart's ligament should be cut only as a last resort.

When reduction has been accomplished by one means or another the contents are inspected for viability. If omentum is involved it is best to resect the involved portion going through obviously healthy tissue. If intestine is present one must decide whether resection is necessary. If there are thrombotic areas in the mesentery or if the peritoneum has lost its gloss and the intestine is soggy and lacking in its normal elasticity resection is indicated. In general if the color and appearance of the strangulated segment fail to improve under the influence of warm saline pads in a ten or fifteen minute period it is safer to assume non-viability and proceed to resect.

The high operation enormously facilitates a resection and immediate anastomosis which is one reason why it is always the method of choice when strangulation is present. In case an operation has been undertaken through the femoral approach and the involved portion of the intestine has slipped back before its viability has been determined it is safer to perform a laparotomy through a lower rectus incision on the same side and examine the strangulated portion for evidence of its integrity, resecting if reasonable doubt exists.

**Injection Method**—Recently much has been written in favor of the injection method of treating hernia. Most writers however are aware of its dangers as applied to femoral hernia. The proximity of the femoral vessels and the danger of damage to them at the time of injection or later due to the effect of the sclerosing solution must be apparent. In my opinion the method is definitely contraindicated for this variety of hernia. As it is quite impossible to maintain at all times complete reduction of the sac by a truss it seems obvious that a cure by this means is out of the question.

**Recurrent Femoral Hernia**—Recurrent femoral hernia often constitutes a difficult problem because in these cases the ring is usually enlarged the structures composing it may have been damaged at previous operation and the landmarks are less clearly visualized. The writer has seen the femoral vein injured in such a case with disastrous consequences. The high approach should al-



ways be used for recurrent cases and use of fascial strips for sutures may be desirable.

**Prognosis.**—The prognosis in cases of femoral hernia must be considered first as to life and second as to cure of the hernia. It may be assumed that unless strangulation occurs life is not threatened. But this complication arises more frequently in femoral than in any of the ordinary types of hernia. According to Watson it is ten times more frequent in femoral than in inguinal hernia. When strangulation has taken place the prognosis depends on the promptness with which surgical intervention is instituted. Since women of advanced age are the most frequent subjects of strangulation it is evident that there is an added factor tending to increase the risk, i. e. the susceptibility to postoperative pulmonary and cardiovascular complications. Gibson in 1900 found a 47 per cent mortality and it is still distressingly high. Watson collected reports of 700 operations for non-strangulated femoral hernia with 9 deaths (1.28 per cent).

The prognosis for surgical cure is also dependent on the age of the patient, the size and character of the ring and its adjacent structures and the care with which the operation is performed. The earlier the condition is recognized and referred for operation the better the prospect of complete cure. Statistics furnished me by Dr. D. H. M. Gillespie, covering 211 consecutive operations performed at the Hospital for Ruptured and Crippled\* (New York), are as follows:

Total no. of operations	211
Recurrences	13 or 6% approx
Deaths	3 or 1.5% approx

#### COLONEL BRADLEY J. COLEY

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\* The name of the hospital has been changed to the Hospital for Special Surgery.

## UMBILICAL AND VENTRAL HERNIA

### UMBILICAL HERNIA

**Definition.**—An umbilical hernia is a herniation or separation in the depression at the middle of the abdomen where the umbilical cord of the fetus was attached.

**Etiology.**—By many authorities all umbilical hernias are considered congenital. For the purpose of classification umbilical hernias may be divided into three forms: (1) congenital hernias due to developmental defects in the midline; (2) infantile hernias which occur soon after birth when the umbilical scar yields to straining, vomiting and coughing; and (3) adult hernias due to excessive intra-abdominal tension caused by excessive intra-abdominal fat, frequently in women and occasionally in men of the laboring class. Multiple pregnancies are a definite etiological factor.

**Pathology.**—At birth the abdominal viscera fail to withdraw within the abdominal cavity coincident with non-closure of the abdominal ring. In some cases the sac contains part of the transverse colon, stomach, liver and rarely gallbladder. In infants and young children when there is weakness in the scar tissue that is normally closed at the umbilicus a small rounded mass protrudes through the navel. These hernias seldom strangulate, are small in diameter and may disappear spontaneously because of contraction of the opening. However, recurrences are likely. In adults umbilical hernia occurs more frequently in men than in women, the proportion being four to one. Gradually but steadily growing, larger some attain an enormous size although as a rule the ring is not large, being approximately 6 or 12 cm. in diameter. The ring is generally round and well defined. Usually many adhesions are found in the sac causing the omentum, transverse colon and often loop of small bowel to become adherent at times form loculated spaces. It is in this type of hernia that strangulation generally occurs.

**Symptomatology.**—Indefinite abdominal distress, dragging sensations, colicky pains, floating nausea, constipation and at times obstipation are the characteristic symptoms.

**Diagnosis.**—The presence of a protrusion at the navel which is partly or entirely reducible and associated in the larger form

mas with diastasis of the rectus muscles denotes an umbilical hernia. It is tympanic on percussion and if a portion of the bowel is included in the sac a gurgling sound is heard. The enlargement of the hernia when the patient is in the erect posture or on coughing and its disappearance in the recumbent position unless the contents are adherent are diagnostic evidence. The larger sacs are prone to ulceration from pressure due to clothing or some type of binder or truss intended to effect a cure. Strangulated umbilical hernias are diagnosed by the presence of a reducible mass in the sac, distention of the abdomen, nausea, vomiting, increased pulse rate, elevated leukocyte count.

seldom is a cure effected without operative intervention. If a hernia is allowed to progress to the stage of ulceration and perforation, peritonitis will cause a fatal termination.

**Treatment**—In infants if the ring is small and if tight and consistent stripping with a properly fitting pad is employed a cure is effected in many instances. In adults surgical management is imperative in order to effect a cure. Proper preoperative prepara-

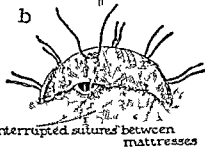
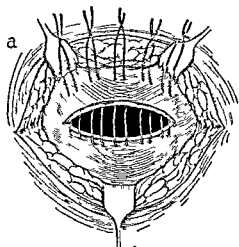


Fig 633—*a* Showing the edges of the true ring with mattress sutures in position ready to be tied. *b* Showing the importance of placing interrupted sutures between the mattress sutures so as to close perfectly any small opening that may exist.

and rising temperature even though no strangulation exists. A mild inflammatory reaction often denotes obstruction in the larger forms which may be either partial or complete.

**Prognosis**—If an umbilical hernia occurs in infancy it may disappear spontaneously. In adults particularly in the obese

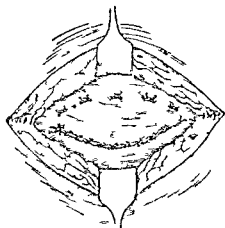


Fig 634—Suturing of "vest over pants" completed. The mattress sutures are tied and the edge of the flap is held in place by a continuous suture.

ration of the obese patient is essential particularly if there is coexistent myocardial disease or a renal disorder. Reduction in weight is necessary if the patient is to withstand operative treatment satisfactorily and if the chances of recurrence are to be minimized. The transverse or "vest over pants" type of repair is preferable to the so-called "vertical" or side to side procedure. The sac should not be opened until it has been completely dissected from the surrounding structures and the surface of the fascia on either side has been well defined. When the sac is opened great care should be exercised in separating the omentum and the loops of large and of small bowel and it is necessary to clear the under surface of the anterior abdominal wall of all bowel or omental attachments for a distance of 3 or 4 inches from the edge of the true ring. The entire sac itself should be excised and only the structures surrounding the ring should be utilized for overlapping. The sac is of little use in the repair. All contents are reduced. In order to

facilitate the overlap an incision is made on either side of the ring. The mattress sutures comprise the first layer, the under flap being drawn well up under the upper flap (Fig. 633 a). A most important point at this stage is the suture of the small spaces between the mattress sutures by means of interrupted carefully placed sutures (Fig. 633 b), as it is at this point particularly that recurrences are prone to occur. The edge of the overlap is then sutured at the surface of the fascia surrounding the inferior border of the ring (Fig. 634). Chronic catgut silk fascial lata from the thigh and ox fascia have been the suture materials used. The anesthesia may be either local or spinal. In the case of a large hernia when difficulty is encountered in closing the ring a patch may be taken from the fascial lata of the thigh to close the defect. In every form of recurrent umbilical hernia, fascia, whether human or from the ox, should be used. Although a longitudinal or side to side repair is occasionally used, the transverse or vest over pants method results in fewer recurrences.

### VENTRAL HERNIA

Any protrusion other than an umbilical hernia which occurs in the anterior lateral abdominal wall is included under the rather ambiguous term of ventral hernia. The important types in this group are: 1 *Epigastric hernias*. These are protrusions of preperitoneal fat which occur in the midline of the abdomen. Most of these occur above the umbilicus and are quite small. In many cases the patient is not aware of the hernia. Epigastric hernias are more common in men than in women. 2 *Hernias of the linea semilunaris*, often resembling a lipoma, appear at the outer edge of the rectus muscle and are due to developmental defects. 3 *Lumbar hernias* occur between the crest of the ilium and the costal margin. For some reason they occur more frequently on the left than on the right side. Strangulation is rare. A congenital weakness of the structures and factors that increase abdominal pressure are the cause of these hernias. They are repaired by means of fascial flaps from below the ilium and turned upward to join flaps deflected downward. Free fascial transplants are also utilized to close these defects. Operative measures have rarely proved to be

successful. 4 *Incisional or postoperative hernias* comprise the largest group of any type of ventral hernia. Hernias produced by stab wounds, crushing blows or gunshot wounds are included in this group. An incidence of 5 or 10 per cent is generally conceded in this particular type of herniation in comparison with all other types of hernia.

**Etiology of Incisional Hernia**—An abdominal operation, particularly when drainage of a wound of the anterior abdominal wall has been instituted, is an important etiological factor. Infected wounds, improper closure of a clean wound and the use of suture material of an inferior grade also are definite factors in the causation of incisional hernias. In the case of an infected wound with large sloughing areas of fascia or the external oblique or rectus sheath, it is easily understood why herniation so readily follows. The smallest piece of omentum protruding through a pinpoint opening in the peritoneum, either in the line of the suture or through a needle tear or slit to the side of either edge, is the incipient pathologic process in a large percentage of cases of incisional hernia. The majority of these hernias start within a few weeks or months following the operation, although many are not noticed for several years. There may or may not be a definite sac. The symptoms are exactly those of umbilical hernia. The diagnosis is readily made by inspection and palpation of the protrusion.

**Treatment**—(a) *Prophylactic*. If possible, prophylactic treatment is preferable. All anterior abdominal wall wounds should be sutured with the utmost care. Particularly great care should be taken in closing securely and firmly the cut edges of the peritoneum and transversalis fascia. Drains should be left in wounds for a minimum period of time. (b) *Operative*. A reiteration of the original anatomical relationship can often be effected but if not a side to side fascial overlap or a vest over pants overlap is usually sufficient to effect a cure. In many cases the use of fascial lata transplants or sutures is indicated and there are instances, particularly in the case of a very large hernia when the repair should be carried out in stages.

HENRY W. CAY

## DIAPHRAGMATIC HERNIA

**Definition**—The term diaphragmatic hernia is commonly used to designate any condition in which there is protrusion of abdominal contents into the thoracic cavity through an abnormal opening in the diaphragm. Any true hernia has a sac as one of its component parts, so that many of the conditions which are included under this term and which do not have a hernial sac would be more properly termed eviscerations or false hernias. The presence or absence of a hernial sac cannot be determined by clinical examination but only at operation.

**Pathology**—There are numerous classifications of diaphragmatic hernia which are based on the embryology, etiology, pathologic anatomy, the site of the opening in the diaphragm, the presence or absence of a sac, the content of the hernia and other conditions. It is difficult or impossible to make most of these classifications clinically and accordingly many of them are of little practical value. Diaphragmatic hernias are therefore usually classified in three main groups: (1) congenital, (2) acquired and (3) traumatic.

From a clinical and surgical standpoint the history of preceding injury is helpful in establishing the diagnosis and in determining the type, urgency and prognosis of operative treatment. Because of the practical clinical and surgical significance of trauma as an etiological factor, the writer has suggested the classification of diaphragmatic hernias into two main groups: *non traumatic* and *traumatic*, and has subdivided these according to the various types as follows:

*Non traumatic diaphragmatic hernias* may be further divided into: (1) the congenital type due to embryological deficiency which is usually without an enclosing sac, the most common sites of occurrence being (a) through the hiatus pleuroperitonealis (foramen of Bochdalek), (b) through the dome of the diaphragm, (c) through the esophageal opening, (d) through the foramen of Morgagni and (e) through the gap left by absence of the left half of the diaphragm; and (2) the type of hernia which is acquired after birth, the sites being (a) through a point of embryological fusion of the dia-

phragm, (b) at sites named under congenital types and (c) through the esophageal hiatus in which case the hernia has an enclosing sac (Fig. 635).

*Traumatic diaphragmatic hernias* may be divided into: (1) hernia due to indirect injury to the diaphragm which may occur at any point including points of embryological fusion but which occurs most commonly in the dome and posterior half of the left side of the diaphragm and usually is the result of a severe crushing injury when the hernia is through the esophageal opening there is a sac and when the hernia is through the leaf of the diaphragm there usually is no sac; and (2) hernia due to direct injury to the diaphragm which may occur at any point and is usually the result of a penetrating wound, e.g. from a gunshot or a knife rupture of a subdiaphragmatic abscess or empyema may also be the cause and usually there is no sac (Fig. 636).

The presence or absence of an enclosing hernial sac is of some practical clinical and surgical importance. A sac is usually not present in a congenital hernia when there has been loss of structure of the diaphragm or in a traumatic hernia due to direct or indirect injury. As has been said this is not a true hernia. Usually several abdominal viscera and a large portion of each involved organ are concerned and the symptoms are very severe and urgent. In the surgical repair of these hernias preliminary phrenicotomy is often advisable and intratracheal anesthesia should be used during the repair. A hernia with a limiting sac is considered a true hernia and it rarely involves more than one organ. The most common hernia of this type is the esophageal hernia in which the stomach is usually the only abdominal organ involved. The symptoms in such cases are more uniform than in others and in the operative repair the sac must either be removed entirely or its continuity with the abdominal cavity obliterated.

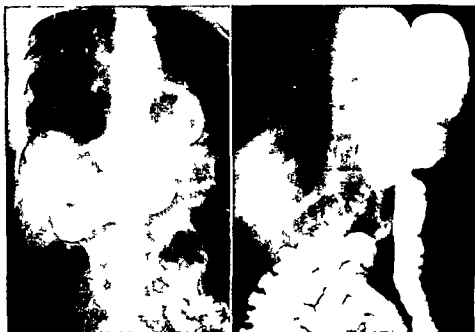
Since the discovery of roentgen rays an increasing number of cases of diaphragmatic hernia have been recognized during life but the incidence of this condition is probably greater than even the present records would indicate. It is of importance to both clinician and surgeon to the clinician because of its

complex symptoms and its importance in differential diagnosis and to the surgeon because surgical repair is the only type of treatment that will relieve symptoms completely.

**Symptomatology**—The clinical recognition of diaphragmatic hernia from the subjective symptoms alone is often very difficult. The symptoms are complex because of the various structures involved in the hernia. They depend on the amount of mechanical interference with the function of the herniated abdominal viscera, the degree of interference with the normal function of the

involved and in which the hernia is usually of the esophageal type, those in the second group occur in cases in which multiple abdominal viscera are involved and in which the hernia is usually of the traumatic type.

**Esophageal diaphragmatic hernias** are usually congenital. The symptoms may begin at birth or at any time during life. There may be a congenital weakness in the esophageal ring and a definite hernia may later be produced by some type of injury or by increased intra-abdominal pressure. These hernias may be considered as of traumatic



F. 63

F. 636

Fig. 63.—Paroesophageal diaphragmatic hernia of moderate size with herniation of approximately half of the stomach into the mediastinum through the esophageal hiatus. The heart shadow is obscured.

Fig. 636.—Traumatic diaphragmatic hernia with herniation of the entire stomach and large loops of the colon into the left thoracic cavity. This caused almost complete collapse of the left lung and the mediastinum was pushed to the right.

diaphragm and on the amount of increased pressure within the thorax which causes impairment of respiration and circulation. The symptoms produced often simulate those of other diseases of the abdomen and thorax of which the most common are cholecystitis, gastric ulcer, cardiospasm, angina pectoris, intestinal obstruction and unexplained secondary anemia.

The symptoms of diaphragmatic hernia may be divided into two main groups. Those in the first group occur in cases in which the stomach is the only abdominal organ in-

volvement and in which the hernia is usually of the esophageal type. Those in the second group occur in cases in which multiple abdominal viscera are involved and in which the hernia is usually of the traumatic type. Esophageal diaphragmatic hernias are usually congenital. The symptoms may begin at birth or at any time during life. There may be a congenital weakness in the esophageal ring and a definite hernia may later be produced by some type of injury or by increased intra-abdominal pressure. These hernias may be considered as of traumatic origin but they are essentially congenital in the same manner as are hernias in the inguinal region. The esophageal type of hernia produces more uniform symptoms than hernias elsewhere in the diaphragm. The symptoms are those of intermittent or progressive incarceration and obstruction of the stomach. At the onset the attacks are usually mild; they consist of epigastric distress which is projected through to the back. They come on during or shortly after a heavy meal and are relieved by belching of gas or by vomiting. These attacks are not uncommonly con-

sidered to be due to disease of the gallbladder. As more of the stomach becomes incorporated into the hernia the attacks become more severe the pain being projected straight through to the back and to the lower left side of the thorax it is more marked to the left of the spinal column and often appears between the shoulder blades. This pain is agonizing and there is difficulty in belching of gas and vomiting because of spasm of the diaphragm and reflex cardiospasm. The spasm of the diaphragm produces hour glass deformity of the stomach which interferes with emptying of the upper loculus and causes increased intragastric pressure. The pressure of the herniated portion of the stomach on the lower part of the esophagus also interferes with belching of gas or vomiting. Spasm of the diaphragm is commonly associated with referred phrenic pain in the left shoulder which at times may be projected down the arm. The increased pressure within the thorax causes cardiac embarrassment with palpitation and tachycardia. The pressure of the lung and the interference with the motion of the diaphragm cause dyspnea. These symptoms are augmented when the patient lies down and in the more severe cases it is necessary for patients to sit up in order to breathe. The attacks may last for from a few minutes to several hours and occasionally are considered to be caused by disease of the arteries of the heart or by myocardial disease. The attacks usually are completely relieved by vomiting and often recur immediately after food is taken.

There is often an interval of weeks or months between attacks. It is probable that during the interval between attacks the stomach is not incorporated in the hernial ring and is in its normal position below the diaphragm. When the attacks become more or less constant this usually indicates that the stomach has become fixed by adhesions in the thorax. All the early symptoms of pressure are augmented during the attacks. There is loss of weight from inability to retain food and from marked restriction in diet resulting from fear of bringing on an acute attack which may be termed a food fear. The vomiting is more severe and often is of the retention type. During severe attacks of vomiting the vomitus may contain blood. If the attacks are of long standing the pa-

tient not uncommonly has a burning sensation in the epigastrium which comes on after meals and is relieved by taking small quantities of food. If large amounts of food are taken it may bring on one of the attacks associated with incarceration of the stomach due to hernia. Often patients obtain partial relief when placed on a diet for ulcer because of the restricted amount of food taken at frequent intervals. Hemorrhage is not a common symptom but it is usually indicative of severe incarceration with fixation of the stomach in the thorax. Bleeding is caused by erosion of the mucous membrane due to the pressure exerted during the attacks of vomiting on the large distended congested and fixed stomach. This erosion may be superficial or in cases of long standing may form a definite ulceration due to repeated trauma. This is usually the final stage of incarceration.

The symptoms of congenital types of diaphragmatic hernia due to structural deficiency in the formation of the diaphragm usually involve multiple abdominal viscera and are often similar to those noted in association with the traumatic types of hernia as there is rarely a confining sac and the herniated abdominal viscera are in direct contact with the thoracic viscera. The symptoms in these cases are often more severe than those noted in cases of traumatic hernia. Because of the occurrence of the hernia at birth the respiratory and cardiac symptoms are usually the most severe owing to the marked unilateral alteration in intrathoracic pressure and the occurrence of this derangement of intrathoracic pressure at a time in which the compensatory respiratory and cardiac reserve has not been developed to a sufficient degree to maintain function of these organs. Many infants born with these congenital defects die in the first few hours or days of life. However if the respiratory and cardiac mechanisms are able to compensate for the presence of these abdominal viscera in the thorax these patients may live on to childhood or even adult life without any great amount of disability or symptoms provided intestinal or gastric obstruction does not develop. There is less likelihood that obstruction will develop in these cases than in the cases of traumatic hernia because there are usually fewer ad-

hesions between the abdominal viscera and the thoracic viscera in the former cases. When the stomach is involved in these hernias it usually becomes markedly dilated and the patients often have symptoms of partial gastric obstruction. Intestinal obstruction may occur because of bands of adhesions between the omentum and loops of

obstinate constipation with accumulation of large quantities of gas in the colon or by periodic attacks of partial or complete obstruction. The sudden onset of symptoms in these cases is usually directly related to the injury; the progress of symptoms is much more rapid and the first symptom may be that of severe gastric hemorrhage or of in-

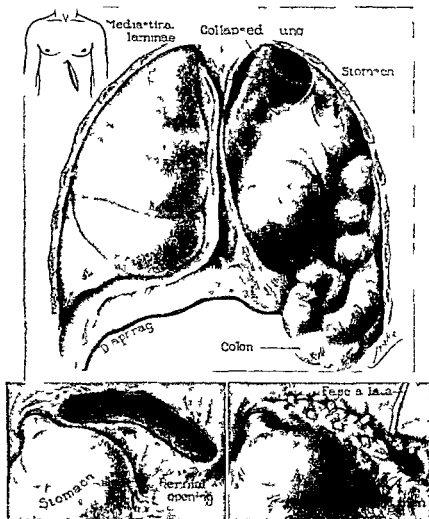


Fig. 63. The entire stomach and a large loop of colon herniated into the left thoracic cavity. The viscera are very adherent to and have collapsed the left lung. Note that the traumatic opening does not involve the large opening which is best repaired after preliminary phrenic nerve interruption.

bowel or because of inflammatory bowel conditions or appendicitis.

The symptoms in cases of traumatic hernia in which the stomach alone is involved are practically the same as those in esophageal hernias, although in most cases of traumatic hernia the colon is involved and there are the added symptoms caused by interference with its function. This may be indicated by

intestinal obstruction. The respiratory symptoms are usually more marked because of the greater amount of viscera contained in the thorax; these viscera are in direct contact with the lung and pericardium as there is no hernial sac.

**Treatment.**—In cases of esophageal diaphragmatic hernia in which only the stomach is involved and in which the symptoms

are mild the treatment may be conservative. In those cases in which progressively more severe symptoms are present the possibility of serious complications is very great, and all of them should be considered surgical cases unless radical operation is contraindicated.

to the diaphragm and structures within the thorax.

In all cases in which the colon or small bowel is involved in the hernia early operation is imperative because of the danger of intestinal obstruction (Fig. 637). These cases

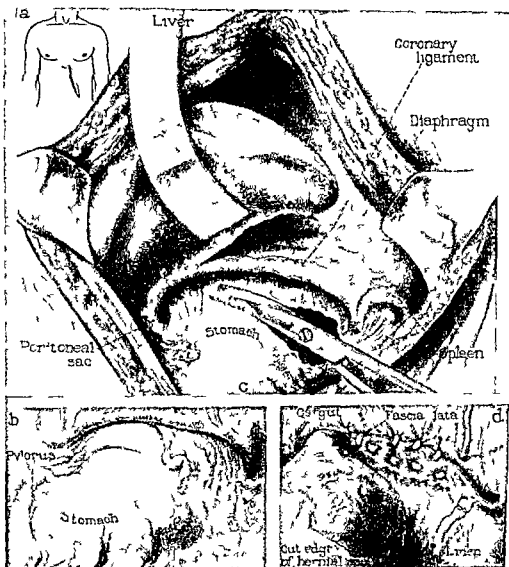


Fig. 638.—The technique of operative closure of the paraesophageal type of diaphragmatic hernia. *a* The oblique left rectus incision. *b* Exposure of the enlarged esophageal hiatus after the left coronary ligament of the liver has been cut. Approximately half the stomach has herniated through the opening. *c* Removal of the peritoneal sac from its attachment to the stomach after the latter has been replaced into the abdomen. *d* Method of closure of the enlarged esophageal hiatus by overlapping the margins of the opening. The tissues are stabilized with linen sutures; the closure is strengthened with living sutures of fascia lata and the esophagus is fixed to the margins of the closed opening with catgut suture.

icated because of the patient's general condition. Surgical treatment should be instituted before severe incarceration with obstruction and traumatic lesions of the stomach have occurred. The operative risk is increased by gastric retention and the technical difficulties are enhanced by fixation of the stomach

are usually traumatic in origin and it is best to delay operation until the acute symptoms have subsided if the patient's condition will permit.

Preliminary paralysis of the diaphragm produced by phrenicotomy is often of value in incarcerated and strangulated hernias be-



cause it prevents spasm of the muscle and relaxes the hernial ring. It is of great advantage in closing a large hernial opening when there is considerable loss of structure of the diaphragm as the relaxation of the muscle permits this defect to be closed without tension and in cases in which the diaphragm has been torn from the wall of the thorax it may be resutured to the intercostal muscles. It is also of value in cases in which there is congenital shortening of the esophagus because the relaxation and elevation of the muscle of the diaphragm following this procedure permit the hernial opening to be sutured around the lower part of the esophagus entirely above the herniated portion of the stomach. It is not necessary however in the small type of hernia in which approximation can be accomplished without undue tension. In some instances in which it seems advisable to reestablish the function of the diaphragm the nerve may be cut and sutured and function will be reestablished within from three to six months.

Phrenicotomy may be used as a palliative measure when the radical operative procedure of closure of the defect in the diaphragm is contraindicated because of the patient's condition. The rationale of this procedure is to prevent spasm of the diaphragm which is the cause of the severe attacks of incarceration of the stomach. The procedure does not completely relieve the symptoms there is always a moderate amount of gastric distress immediately or shortly after a heavy meal but the patient gets along fairly well on a restricted diet. Phrenicotomy completely relieves the acute attacks of incarceration if the stomach is not fixed in the thorax. It is not applicable to a hernia in which a large portion of the stomach is in the thorax causing marked pressure on the heart and lungs nor is it applicable in any case in which the intestines are involved in the hernia.

The only operative procedure which will assure complete relief of symptoms is replacement of the herniated abdominal viscera and repair of the abdominal opening in the diaphragm (Fig 638). The writer prefers the abdominal approach because there is little risk of thoracic complications. The thoracic approach gives excellent exposure and is preferred by some surgeons. In cases in which the abdominal viscera are adherent

to structures in the thorax these adhesions can be separated through the hernial ring with little danger of injury to the abdominal or thoracic viscera as the definite relationship of the herniated structures can be established. The presence of associated lesions in the herniated abdominal viscera can be determined as well as of any other pathologic lesion within the abdomen and there is no deformity following operation.

The postoperative care is of great importance in all cases but it is of particular importance in those cases in which there has been marked pulmonary collapse over a long period. In such cases there may be some delay in expansion of the lung following operation because of adhesions produced by the continuous collapse. There is often some difficulty at the time of operation in obtaining immediate expansion of the lung although every effort is made to expand the lung by positive pressure apparatus and also by suction of the air from the pleural cavity before the diaphragm is completely closed. In some of these cases the lung remains collapsed because of pneumothorax as the result of positive pressure which swings the mediastinum to the opposite side and embarrasses the heart. In these cases air must be aspirated immediately from the thoracic cavity following which the mediastinum returns to its normal position and the symptoms disappear rapidly. All of these patients are often greatly benefited by being placed in an oxygen chamber immediately after operation and in those cases in which there has been serious pulmonary collapse this may be a life-saving procedure. Pleural effusion in the side of the thorax on which operation has been performed is not uncommon. The fluid may absorb without aspiration or it may require repeated aspirations.

STUART W. HARRINGTON

## UNUSUAL HERNIAS

### INTERNAL HERNIA

*(Retroperitoneal and Intrapertoneal Hernias)*

**Definition and Classification** — An internal hernia is a protrusion or extension of a sac of peritoneum containing intra abdominal contents through a normal or abnormal

aperture or structure and is confined within the abdominal cavity. Of the many classifications, that of Steinke is the most simple and comprehensive: I Retroperitoneal: A. Paraduodenal: (1) right, (2) left, (3) duodenojejunal B. Paracecal: (1) ileocecal (superior or inferior), (2) retrocecal, (3) ileocolic. C. Inter-sigmoid. D. \*Foramen of Winslow. II. \*Anomalous openings: A

through which the small intestine migrates to become retroperitoneal. The intestine pushes a sac of peritoneum ahead of it.

Andrews and Papez have presented good evidence that these hernias are congenital anomalies produced during the second stage of intestinal rotation. If, during rotation, the umbilical midgut loop is oriented in a reverse direction, it is possible for the small

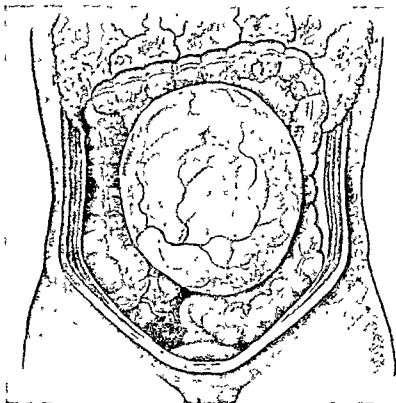


Fig. 639.—Retroperitoneal paraduodenal hernia (after Wangensteen)

Through the mesentery. B. Through the omentum. C. Through or into the broad ligament.

**Incidence, Etiology and Pathology.**—Internal hernias are rare. A comprehensive but inexhaustive review of the literature revealed the following totals of reported cases, paraduodenal, 248; paracecal (excluding adhesive bands), 18; foramen of Winslow, 35; anomalous openings, 39

There prevail two very different opinions relative to the origin of the retroperitoneal hernias. Trietz and Moynihan postulated that the normal paraduodenal, paracecal and sigmoid fossae or abnormal ones, due to failure of fusion during the third stage of intestinal rotation, develop into apertures

\* Not a true hernia: absence of peritoneal sac

intestine to become incarcerated in its own mesentery or that of the large bowel

In these cases the entire small intestine or a large portion of it is found imprisoned in a sac which is retroperitoneal. It may occupy a central position in the abdomen with the large bowel in its normal location (Fig. 639), or it may occupy the right half of the abdomen with the entire large bowel on the left side. The mesenteric vessels are disposed or stretched tightly about the aperture.

In a hernia of the foramen of Winslow, either small or large intestine, usually the colon, is found protruding through the foramen into the lesser peritoneal cavity.

On rare occasions a loop of bowel has herniated through an abnormal aperture in the broad ligament, in the great omentum or in

the various mesenteries. These apertures are either anomalous defects or result from disease from trauma (penetrating or non penetrating wounds) or from surgical procedure.

**Symptoms**—Many of these hernias have been reported as incidental findings at operation and routine postmortem examination and in these cases it may be assumed that they gave rise to few or no symptoms. In most of the other cases in which the diagnosis was confirmed at operation or necropsy there were typical signs and symptoms of intestinal obstruction usually with strangulation. A few patients had indefinite pain and dyspepsia others had symptoms of intermittent or chronic partial obstruction.

**Diagnosis**—Seldom has an internal hernia been recognized preoperatively, but as pointed out by Case this should be possible in many instances with the aid of special roentgenographic studies. The usual diagnosis has been intestinal obstruction cause undetermined. The mass of distended bowel has been mistaken for a cystic tumor. In the absence of symptoms of obstruction many intra abdominal lesions may be simulated.

**Prognosis**—Unless these hernias become obstructed they do not influence normal life expectancy. Obstructed paraduodenal and foramen of Winslow hernias usually terminate fatally. In the other types the mortality is approximately 30 per cent.

**Treatment**—If reducible the hernia should be reduced and the fossa or aperture obliterated. If strangulation necrosis has occurred the necrotic segment of bowel should be resected or if the patient is a high risk simply exteriorized with an anastomosis to restore continuity of the intestine at a subsequent operation. Unfortunately it is seldom possible to reduce a paraduodenal hernia or hernia through the foramen of Winslow and the situation is hopeless. Failure results from inability to enlarge the ring sufficiently to release the bowel because the ring contains such indispensable structures as the mesenteric vessels in the former group and the hepatic artery portal vein vena cava and common bile duct in the latter.

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## PFLVIC HERNIA

### OBTURATOR HERNIA

(*Subpubic Hernia Thyroidal Hernia Hernia through the Foramen Ovale*)

**Definition**—As indicated by its name this hernia protrudes through the obturator foramen into the thigh.

**Etiology and Pathology**—It is the most common of the rare hernias with more than 400 cases on record. Most of the patients were women over sixty years of age. The sex ratio was 6 women to 1 man, the difference being attributed to pregnancies and the larger foramina in women.

The obturator foramen is occluded by the obturator membranes and muscles except for three small openings through which the obturator vessels and nerves pass. The hernial sac may leave the pelvis through any one of these foramina passing downward for ward and medially to appear under the edge of the pubic bone. The sac is usually located between the obturator externus, the pectineus and the adductor muscles in the lower portion of Scarpa's triangle. It usually contains small intestine rarely large bowel or tubes and ovaries. Strangulation is a common complication and was present in the majority of the reported cases.

**Signs and Symptoms**—There are two groups of symptoms those attributable to the constriction of the bowel and those resulting from pressure upon the obturator nerve. In the former group there are vague reflex gastrointestinal manifestations but no characteristic symptoms until obstruction takes place. There follow then the usual symptoms of obstruction and often also those of strangulation.

Pressure on the obturator nerve gives rise to a rather typical syndrome known as the Howship Romberg syndrome. It is manifested by tingling a burning sensation numbness or pain along the anterior mesial aspect of the thigh and around the knee joint. Straining and coughing increase the pain.

Occasionally micturition is difficult and frequent. These symptoms may appear with the onset of obstruction and strangulation, or if previously present, they are increased in intensity with the onset of obstruction. To relax the muscles around the obstructed bowel, the patient holds the leg in slight flexion, adduction and internal rotation.

Usually it is impossible to palpate the hernia in the thigh, but occasionally there is an obvious swelling and a palpable mass on the inner aspect of the thigh below and medial to the femoral canal or in Scarpa's triangle. It is always possible to feel the neck of the

A considerable reduction could be effected by earlier diagnosis and surgical intervention.

**Treatment.**—Manual reduction of these hernias is impossible, and because strangulation is probably inevitable, surgical intervention is urgently indicated whenever the condition is diagnosed. The hernia can be dealt with by an approach through either the thigh or the abdomen or a combination of the two. The abdominal approach is the more satisfactory. The ring is more accessible for enlargement, and reduction can be accomplished by traction on the bowel while

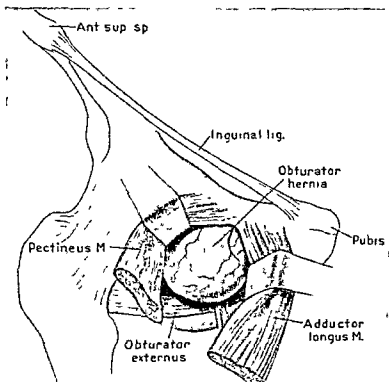


Fig 640—Obturator hernia\*

sac by vaginal or rectal examination. This examination is a decisive factor in making a diagnosis and is another example of its importance as a routine procedure.

**Diagnosis.**—An accurate preoperative diagnosis has been made in less than one fifth of the reported cases. It has been mistaken for femoral hernia, adenitis, psoas abscess, varicose veins, phlebitis and disease of the hip joint.

**Prognosis.**—As a result of the high incidence of strangulation and the unskilled handling of these hernias, the mortality has been very high, approximately 75 per cent.

pressure is exerted upon the thigh. Resection, when necessary, is accomplished more readily within the abdomen.

To expose the sac in the thigh a longitudinal incision is made in the medial portion of Scarpa's triangle, the pectineus muscle is exposed and retracted laterally or divided and the adductor longus muscle is retracted medially. This exposes the sac, which, with its contents, is dealt with as in the case of a femoral hernia. Similarly, after excision of the sac the foramen is obliterated to prevent a recurrence of the hernia.

\* *Jason's Hernia*, The Blakiston Co., Publishers

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## PERINEAL HERNIA

In this type of hernia there is a protrusion of intra abdominal contents through the pelvic floor into the perineum. The sac dissects downward between the rectum and the neck of the bladder prostate and urethra in the male and between the rectum and vagina in the female.

Most of the hernias occur in women and are of two types anterior vaginal and posterior rectal. When small the anterior hernia protrudes into the labia majora. The larger ones compress the vagina laterally and extend backward to the edge of the anus. The hernia can be traced by palpation along the vaginal wall to its point of origin in the pelvis and in this way an accurate diagnosis can be made.

Because these hernias are rare they are not suspected and are mistaken for the labial form of inguinal hernias and vaginal cysts fibromas and lipomas. A few strangulated hernias have been treated as acute inflammatory lesions by incision and with disastrous results.

The posterior or rectal type emerges behind the transverse perineal muscle and compresses the rectum to bulge into the ischio-rectal fossa. A strangulated hernia of this type may be mistaken for an ischio-rectal abscess and incision for drainage is followed by a fecal fistula or peritonitis.

Failure to recognize these two types of hernia has resulted in several surgical catastrophes. It is possible to reduce these hernias through a posterior colpotomy and to close the hernial aperture by approximating the uterosacral ligaments or by a modified perineorrhaphy. The intra abdominal approach is preferable because it affords a more adequate exposure for a safer reduction and a more secure repair of the pelvic floor. It is the only approach through which a non reducible and strangulated hernia can be handled.

The author has observed a third type of perineal hernia which occasionally occurs following resection of the rectum. The hernia

dissects through the space formerly occupied by the rectum. In one case the hernial sac bulged through the unhealed perineal wound and prevented healing until it was reduced and the skin sutured over it. The hernia in the other case caused a large bulge of the healed perineal wound.

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## SCIATIC HERNIA

This type of hernia protrudes from the pelvis into the thigh through the small or great sciatic foramen. The sac usually contains the intestine or omentum or both and occasionally the bladder or an ovary. As the hernia emerges into the thigh it passes either above or below the piriformis muscle to occupy the space under the gluteus maximus muscle. These hernias may be classified as the superior and inferior gluteal types the former dissecting along the superior gluteal artery and the latter in the periarterial space of the inferior gluteal artery.

Sciatic hernias are probably the rarest of the rare hernias. Less than 50 cases are on record and most of these have been reported as incidental necropsy findings.

From this fact it would appear that most of these hernias give rise to few or no symptoms and that their presence is unrecognized during life. Pressure on the sciatic nerve may produce pain along the distribution of this nerve. A few cases have been reported in which there was a tender swelling in the gluteal region, the swelling enlarged with straining and transmitted an impulse with coughing. Furthermore the swelling was readily reducible and apparently strangulation seldom occurred.

In the event that an accurate preoperative diagnosis is made, these hernias are best dealt with through an intra abdominal exposure. The contents of the sac are returned to the abdomen, the sac resected and the foramen closed by utilizing the neighboring fascia and piriformis muscle. The operation can be carried out satisfactorily also through an incision extending from the posterior spine of the ilium to the border of the greater trochanter of the femur. Division of the gluteus maximus muscle exposes the sac

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## LUMBAR HERNIA

*(Hernia Dorsalis, Petit or Grynfelt Hernia)*

These hernias appear in the lumbar region and may be divided into two general groups—congenital and acquired. The acquired type may develop spontaneously or may follow trauma. The traumatic group is composed principally of postoperative or incisional herniations and most of these fol-

and the anterior border of the latissimus dorsi posteriorly. The superior space is less well defined and opinions vary regarding its boundaries. For the purpose of this presentation it may be said that it is bounded by the twelfth rib superiorly, the erector spinae muscles medially and the superior edge of the internal oblique laterally.

Most lumbar hernias have a large neck and give rise to no symptoms. There is as a rule, an easily reducible mass which transmits an impulse on coughing. A few patients complain of reflex gastrointestinal symptoms or a vague dragging sensation in

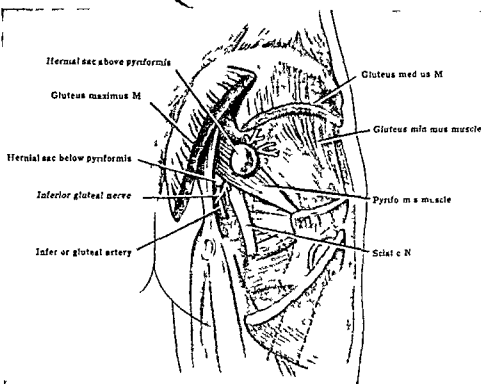


Fig. 641—Types of sciatic hernia.\*

low an operation upon the kidney. Occasion- ally a hernia develops in a large defect in the lumbar wall from a penetrating wound and infection. Lumbar hernias occur mainly in men and twice as often on the left as on the right side.

The congenital and spontaneously acquired hernias are rare. They protrude through two spaces, the inferior and the superior lumbar. The inferior one is known as Petit's triangle, which is located subcutaneously and is bounded by the posterior border of the external oblique muscle anteriorly, the crest of the ilium inferiorly

the ilium. Incarceration or strangulation is rare; only 18 cases having been reported.

The differential diagnosis involves consideration of lipomas, fibromas, primary or metastatic malignant neoplasms, cold abscesses and paralytic scoliosis.

In most cases no treatment is required. An abdominal supporter or corset may relieve vague discomfort and prevent the hernia from enlarging. Operative treatment is indicated for the rare hernia which is large, strangulated, or the cause of much distress. It consists of disposing of the sac if

\* Iason: Hernia. The Blakiston Co. Publishers.

present and repair of the defect in the lumbar wall. This may be accomplished by approximating the edges of the muscle and fascia or may necessitate the reflecting of a pedicle flap of fascia to cover the defect. Such a flap may be fashioned from the lumbar fascia or the fascia lata covering the gluteal muscles.

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### SLIDING HERNIA

(*Hernie engluissade*)

**Definition**—This type of hernia is characterized by a sac composed only partially of parietal peritoneum. A portion and occasionally all of the sac is made up of large bowel or bladder which protrudes through the ring. The retroperitoneal surface of the organ presents as the external surface of the sac in the inguinal canal.

The terms sliding and landslide have been applied to these hernias upon the assumption that the large bowel or bladder slides with the peritoneum from the retroperitoneal fat and areolar tissue to which it is very loosely attached and is dragged by the peritoneum through the ring. As contributing factors it has been suggested that the bowel following rotation becomes fused to the parietal peritoneum at or near the internal ring or that it is dragged down to the ring with descent of the testicle. Brown believes that there is no sliding mechanism involved. He contends that in the beginning these hernias are ordinary ones with a complete sac and that subsequently inflammatory adhesions develop between the bowel and the peritoneum of the sac thus eliminating a portion of the sac.

Many hernias of the large bowel and bladder are not sliding hernias but like small bowel and omentum these organs merely descend into an ordinary complete sac and constitute no part of the sac.

**Incidence**—Sliding hernias are uncommon. Statistical reports vary widely but they probably constitute less than 3 per cent of all hernias. Unquestionably the bladder is present in the wall of a direct hernia

more often than is suspected because it is customary merely to push back the sac without opening it or determining its contents. Sliding hernias occur almost exclusively in men and usually in elderly men.

**Pathology**—A sliding hernia of the bladder is found principally in a direct sac only occasionally in an indirect one. The normal wall or a diverticulum of the bladder moves laterally and presents in the pubic end of the inguinal canal where it is covered only by retroperitoneal fat.

Sliding hernias of the large bowel are almost exclusively of the indirect type. They occur about equally on the two sides and always through a very large dilated internal ring. The ring usually extends down to the pubis and occupies the entire floor of the inguinal canal. On the right side the sac contains the ascending colon and cecum and on the left the descending colon or sigmoid. Occasionally the right colon is found in the left inguinal canal.

Bilateral sliding hernias are not rare. The writer has encountered 3 cases. Rare instances of sliding femoral hernias have been reported.

**Symptoms**—There are no characteristic symptoms unless it be the occasional occurrence of dysuria in herniations of the bladder. The symptoms are those common to hernias in general and the diagnosis is seldom made prior to operation. As a rule these hernias cannot be retained satisfactorily with a truss.

Owing to the large size of the ring strangulation seldom occurs. Occasionally appendicitis, diverticulitis or a tumor develops in the bowel within the sac.

**Treatment**—Sliding hernias and their operative management have received too little consideration in surgical instruction. Although uncommon these hernias are very important because they present to the unsuspecting uninformed surgeon a very perplexing problem fraught with grave hazard. The custom in many teaching clinics to delegate the operative management of hernias to the relatively inexperienced members of the staff and interns has resulted in some unfortunate disasters.

Unless the character of these hernias is recognized early in the course of the operation the bowel or bladder may be opened

accidentally in the attempt to isolate or open the sac. Also in the course of dissection the circulation of the bowel may be injured. These accidents are likely to result in disaster from flooding the operative field with urine or feces or may necessitate resection of a segment of bowel to prevent gangrene from disruption of its blood supply. The surgeon is warned that he is approaching the retroperitoneal surface of the bladder or bowel first by encountering a densely lobulated and fibrous type of fat quite different from the loose fat of the inguinal canal. With further dissection he encounters profuse venous bleeding from the rich plexus of veins on the surface of the bladder or exposes the mesenteric vessels of the bowel. Further warning is given by encountering the unmistakable muscular wall of the bladder or bowel. Since a sliding hernia of the bladder occurs mainly in a direct bulge there is seldom need for opening or exploring the sac. Should the bladder however be accidentally opened it should be closed immediately with two rows of sutures, the wound drained and the bladder kept empty for one week with constant urethral catheter drainage. In case the bowel is accidentally opened no attempt should be made to repair the hernia and the bowel should not be returned to the peritoneal cavity following simple closure unless some type of decompression is provided. It is safer to leave the bowel wall exteriorized from the peritoneal cavity in the wound with or without a catheter in the bowel.

For hernias of the indirect type several plastic operations have been devised such

as those described by Hotchkiss and Lenormant. In addition to repairing the hernial canal these operations attempt to fix the bowel at some distance above the internal ring by plication or by extensive mobilization and fixation. In the opinion of most surgeons there is little to be gained from these more extensive operations. It is only necessary to mobilize the bowel sufficiently to make possible its return down to the internal ring. The inguinal canal is then repaired by one of the several methods used for the repair of inguinal hernia. The writer prefers an operation which he described for the repair of direct inguinal hernias. This operation utilizes a strip of pectineus fascia and muscle as a deep bulwark in addition to a modified Bassini type of repair utilizing a strip of external oblique fascia as a living suture as described by McArthur. Duncan has recommended division of the cord so as to permit complete closure and elimination of the internal ring. He states that atrophy of the testicle does not necessarily follow.

The incidence of recurrence is fairly high regardless of the type of operation used. Records show a recurrence rate of 10 to 40 per cent.

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## XXXIV. THE GENITOURINARY TRACT

### THE ANATOMY AND PHYSIOLOGY OF THE GENITOURINARY TRACT

The kidneys are situated opposite the lower thoracic and lumbar portion of the vertebral column. Each kidney weighs from 125 to 170 Gm., those in females being slightly smaller. Anteriorly the kidneys are in contact with the abdominal viscera such as the spleen, pancreas, colon and stomach. These relations are important in trauma to the kidney as the overlying structures are sometimes involved.

The kidneys are not held in place by any distinct ligaments or special folds of peritoneum but for fixation depend to a large extent on the pressure and counterpressure of the neighboring structures and on their connection with the renal fascia. The kidneys are

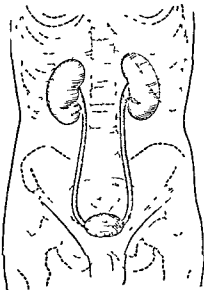


Fig. 612—Diagram showing relationships of kidneys, ureters and bladder.

enveloped and supported by a layer of connective tissue derived from the extraperitoneal areolar tissue which in many cases contains abundant lemon yellow fat. This fascia has an anterior and posterior layer and is closed above and laterally but is open below and medially. Hence most displacements of the kidney are medial and downward.

For anatomical consideration the kidney can be divided into two parts, the glandular and the collecting portions which consist of the parenchyma and the pelvis and calices respectively. The glandular or functional unit of the kidney consists of a glomerulus and its tubule. These tubules drain the urine into the renal pelvis which is a thin walled expansion of the upper part of the ureter. At the hilus of the kidney the pelvis lies posterior to the renal vessels. This is helpful in

determining whether an excised specimen is the right or left kidney.

The renal arteries come from the aorta and the renal veins drain into the vena cava. The renal nerves come from the three lower thoracic and the lumbar segments of the spinal cord. The kidney has no lymphatics.

The ureter is a hollow muscular tube which carries the urine from the renal pelvis to the bladder, its average length is about 25 cm and it is retroperitoneal throughout its length. The ureteral lumen is about 4 or 5 mm in diameter. It is narrower at its origin at the termination in the bladder and at the junction of its abdominal and pelvic portions. It is at these points that stones traversing the ureter become lodged. A 2 mm catheter is usually employed for catheterization. The ureter enters the bladder wall obliquely. The intramural portion of the ureter is about 2 cm long. In the male the spermatic vessels and ductus deferens cross obliquely in front of the ureter near its junction with the bladder. In the female the ureter passes forward at the base of the broad ligament and forms the posterior and inferior boundaries of the ovarian fossa and is found 1.5 cm lateral to the supravaginal cervix uteri. The ureter passes below the broad ligaments ("water flows under the bridge").

The bladder is a hollow muscular viscus which serves as a reservoir. When empty it lies almost entirely in the pelvis when distended it rests in the abdominal cavity behind the rectus muscles and may reach as high as the umbilicus. The bladder is long and narrow in the infant and when filled extends relatively higher into the abdominal cavity. The average capacity is about 0.5 liter in the adult, its capacity is said to be slightly greater in the female. The top of the bladder is connected with the umbilicus by a fibrous cord, the remnant of the urachus which may be the site of tumors or cysts of embryonic origin. The neck or outlet of the bladder is continuous with the urethra and in the male is surrounded by the prostate gland.

The nerve supply of the bladder comes from two sources, the sacral segments supplying the pelvic nerves and the upper lumbar segments supplying the hypogastric fibers. The arteries to the bladder are from the internal iliacs and the middle hemorrhoidal artery. The lymphatics accompany the veins and terminate in the hypogastric nodes.

**The Male Reproductive Organs.**—The two testes are suspended in a fibromuscular sac, the scrotum. Within the scrotum they are enveloped in a serous sac, the tunica vaginalis which contains a small amount of fluid. When this fluid is excessive it is known as a vaginal hydrocele. Each testis weighs about 20 Gm and is composed of a tubular parenchyma which contains the seminiferous tubules and the collecting tubules which enter the epididymis (Fig. 613). The testis in embryonic life is an abdominal organ held in position

by the gubernaculum testis by which it is attached to the bottom of the scrotum. In its descent it passes through the inguinal canal, being preceded by a pouch of the peritoneum. The secretion of the testicle is conveyed to the seminal vesicles by the vas deferens, from which the secretion empties during orgasm into the posterior urethra by way of the ejaculatory ducts.

The seminal vesicles are two finger-like diverticulated sacs which serve as reservoirs for the semen and are situated between the bladder and rectum. The vesicles can occasionally be palpated with the gloved finger in the rectum.

The penis is composed of three rod-like segments firmly united together by a sheath of fascia and skin. Of these three erectile segments the corpus spongiosum is traversed by the urethra which at its distal end expands to form the glans penis. The glans is separated from the body of the penis by a constriction, the coronal sulcus. On the ventral surface of this sulcus the frenulum contains vessels of some size which may bleed profusely during circumcision or from rupture due to trauma.

Cowper's glands (bulbourethral) are two pea-sized organs which lie in the membranous urethra. They secrete a thin alkaline fluid and are frequently infected in gonorrhea and may be the site of abscess formation.

The male urethra is about 20 cm long and is lined with laminated epithelium. The course of the urethra resembles the letter S but a straight instrument can be passed from the tip of the penis into the bladder. The external meatus varies in size and sometimes must be enlarged for the passage of sounds. On the dorsal wall of the urethra there are many small simple and compound mucous glands (glands of Littre) which are also found in the membranous and prostatic urethra. These glands are almost always infected in gonorrhea.

**Physiology of the Genitourinary Tract**—The kidney has a number of known functions and it is not improbable that it has some functions still unknown. The most widely known and studied function is that of the formation of the urine. It serves to eliminate waste products of nitrogenous nature as well as excessive water and salts. The kidney in some instances elim-

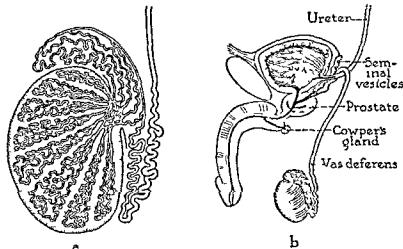


Fig 613—*a* Diagram of anatomy of the testicle and epididymis *b* diagram of anatomy of urinary bladder and external genitalia in the male

The prostate is a glandular structure which encircles the neck of the bladder and is perforated by the proximal end of the urethra. It is comparable to a chestnut in size and dimension, its apex pointing downward and its base lying under and against the trigone of the bladder. It weighs about 25 Gm. With the finger in the rectum the posterior surface can be palpated. In addition to glandular tissue, the organ contains an external layer of unstriated muscle which extends between the glands forming a stroma. The portion of the prostate in front of the urethra is almost entirely muscular and contains some striated fibers which form the external sphincter of the bladder. Unstriated fibers embrace the vesical orifice and prevent the backflow of semen during intercourse. The glands are of a branched tubular type and open through about 15 or 20 orifices into the posterior urethra. In addition there are true glands in a number of simple follicles in the anterior wall of the urethra. Because of the location of the prostate disturbances of the organ cause dysuria and dysfunction of the bladder.

inates foreign products which have been introduced into the body. Under average conditions all the glomeruli do not receive blood or function continuously but appear to work intermittently depending on the demands of the body. The administration of caffeine causes many of the glomeruli to become filled with blood and thereby causes diuresis. The rate of the blood flow through the kidney markedly influences the formation of the urine. Constriction or passive congestion of the renal vessels decreases or prevents the production of urine. Clamping of the kidney pedicle for longer than thirty minutes definitely injures the kidney, causing anuria and permanently scattering the parenchyma. When there is a block of the ureter the kidney will secrete until the pressure rises to 80 mm of mercury. At night the circulation is diminished and the amount of urine formed is less than that formed during the day, usually at night the amount does not exceed 450 cc. When the amount equals or exceeds that excreted during the day, it is an indication of renal impairment or cardiovascular disease. The kidney has

a normal output of about 30 Gm of urea but this will vary with the daily nitrogen intake. The kidney has the ability to put out either highly concentrated urine or very dilute urine. When an extreme amount of water is drunk the specific gravity of the urine may be as low as 1.001 and if water is withheld or excessively eliminated by other avenues of the body the concentration may be as high as 1.030. When the kidney fails to have the ability to concentrate and dilute the urine promptly it is evidence of renal disease. The intravenous injection of saline solution causes a diuresis which tends to reestablish the normal balance between the blood and the tissues. If salt or Ringer's solution is given by mouth or rectum so that it passes through the intestinal mucosa and liver for some unknown reason it is retained in the body to a greater extent than when given parenterally. Digitalis when indicated for cardiac decompensation causes diuresis by improving the circulation through the kidney. Mercurial diuretics act primarily on the kidneys it is thought that they prevent reabsorption in the tubules. If there is an excess of fluid lost through other channels of the body such as by vomiting, perspiration, diarrhea, etc., the volume of urine will be decreased.

Nerves pass to the kidney and so far as is known they are entirely vasomotor since there is no evidence that the kidney receives secretory nerves. There occurs in man a condition known as emotional diuresis or glycosuria and an emotional albuminuria which may be due to nervous or hormonal stimuli. Urinary flow is thought to be influenced by certain visceral reflexes. These reflexes are not so difficult to demonstrate in experimental animals. Ureteral trauma in the dog causes a reflex anuria. Clinical cases have been reported in which injury or disease in one kidney has reflexly caused the other kidney to cease functioning. Certain skeletal stimuli such as electrical stimulation of the sciatic nerve will cause a marked change in the volume of the kidney and will increase or decrease the urinary flow. The application of heat or cold to the body surface likewise influences the renal function, cold decreasing the formation of urine and heat increasing the urinary flow. Postoperative anuria may be due to the combination of a number of factors such as reflex vasoconstriction, congestion and inadequate cardiac function and dehydration, pre-existing disease of the kidneys or heart may predispose to anuria.

In the estimation of renal function many tests have been devised the details of which are to be found in manuals on laboratory diagnosis.

The urine which collects in the pelvis of the kidney, is periodically discharged down the ureter. The flow down the ureter is facilitated by peristaltic waves which occur at a rate of from three to five per minute. The rate depends usually on the urinary outflow. The ureter will function adequately when all extrinsic nerves have been removed probably owing to the fact that it contains ganglionic cells and an intrinsic plexus. An injury or stricture involving more than two thirds of the ureteral circumference will inhibit the passage of a peristaltic wave and the portions above and below the site of injury retain their power of peristalsis but owing to lack of synchronization between the two segments dilatation of the upper segments occurs. Afferent nerve fibers from the ureter go

to the renal plexus and thence to the spinal centers. The passage of blood clots or clumped cellular debris through the ureter gives rise to pain. Distention of the ureter also gives rise to pain as does the passage of catheters in some instances. When a stone is impacted in the ureter preventing the outflow of urine from the kidney severe pain results. Usually the passage of a catheter above the obstructing stone causes cessation of the pain. A valve-like mechanism at the ureterovesical junction prevents the backflow of urine from the bladder up the ureters. In certain types of obstructive uropathy and occasionally even in normal persons a vesicoureteral reflux occurs. This is more likely to obtain in children. The control of the ureterovesical sphincter appears to be inherent in the musculature of the ureter and bladder.

The bladder as it gradually fills contracts rhythmically, and these contractions become greater in amplitude as the filling continues. When the capacity of the bladder is reached a contraction results in the "call to urinate" which, if responded to results in a sustained contraction and the opening of the vesical sphincters. If the "call to urinate" is not responded to the threshold of the bladder is set at a higher tension level. Infants as a rule void after the first stimulus reaches the spinal reflex centers. In the adult these spinal centers are entirely under control or influence of the cerebral cortex. After the higher centers have gained control the spinal centers although stimulated, are not released to act until the higher centers withdraw their inhibitory influence. When children are being taught voluntary control they may void during sleep. This means that the higher inhibitory mechanism has not yet gained complete control over the lower centers, as is manifest in the adult.

The loss of function of either one of the sphincters does not result in incontinence of urine; the function of both sphincters must be lost before incontinence ensues. In the so-called cord bladder which is often seen in spinal syphilis the bladder loses its sensitivity so that impulses to empty the bladder are not received and overdistention occurs. Some of the urine is forced out of the bladder from time to time causing a paradoxical incontinence—an incontinence with a full bladder. A true incontinence is said to be present when the bladder ceases to act as a reservoir, owing to paralysis of the sphincters and the urine passes into the urethra without disturbing the bladder.

The main functions of the testes are three in number: the formation of sperm for procreation, the development of the accessory sex organs and the development of the secondary sexual characteristics of the male. The latter functions are maintained by an internal secretion called androsten.

The loss of the testes before puberty results in a condition of eunuchoidism which may be either of two types: one in which the bony skeleton is elongated and the person thin and tall the other in which the person is usually short and stout. The prostate and seminal vesicles and the penis are infantile forming no secretion. When the testes are lost after puberty the subject attains an adult-eunuch appearance. This is not as characteristic as in the puberty castrate. Most castrates have an abnormal distribution of fat about the hips, they lack hair on the face or the recte

may change slightly. The accessory sex organs atrophy, and no secretion is elaborated. The sex urge however may be present or absent. This manifestation in some instances has been retained several years after castration. In those mammals which have scrotal testes there is occasionally a retention of one or both of the testes in the abdomen. This condition is known as cryptorchidism. When both testes fail to acquire a scrotal position sterility results. Ordinarily an undescended testicle contains Sertoli's cells but few if any germinal cells. Replacement of the testes into the scrotum in most instances is followed by the recovery of the spermatogenic function. Operations for cryptorchidism should be performed before the onset of puberty. The scrotal sac serves as a thermoregulator and produces a localized environment cooler by several degrees than other parts of the body. The testes require such a temperature for the production of germinal cells.

The internal secretion of the testicles controls the growth of the accessory sex glands and secondary sexual characteristics. The maturation and descent of the testicles are dependent on the anterior lobe of the hypophysis. Administration of hypophyseal extract does not seem to affect the amount of testicular secretion in a normal animal. There is no evidence that a testicular hormone is stored in the body, immediately after castration involuntary changes occur in the accessory sex organs. The testicular hormone stimulates the growth of male accessory sex organs but has no effect on the testicle or the elaboration of the testicular hormone. Gonadal hormones of either sex exert a depressing effect on the anterior lobe of the hypophysis.

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#### UROLOGIC DIAGNOSIS

**Plan of Diagnostic Study.**—The first suspicion of involvement of the urinary tract is usually obtained from symptoms, past or present, and from a routine examination of the urine. Hence a complete history must always be obtained with detailed information as to pain and urinary irregularities. From this knowledge alone may be obtained clear indications of the region probably involved and even of the nature

of the trouble. Next in order follows a careful and complete physical examination, including inspection and palpation of the external genitals, a rectal examination, a vaginal examination in women, a neurological investigation especially for lesions of the spinal cord and urine analysis. Finally come the special examinations—instrumental and roentgen examinations, renal function tests and determination of the chemical constituents of the blood. Emphasis is placed on the necessity for completeness of the examination up to the special investigations. Some enthusiasts stress the desirability of following through with certain of these special tests as a routine in all cases. While it is true that such a procedure will occasionally disclose unsuspected abnormalities common sense and experience in urology will decide when the probabilities of enlightenment will warrant the additional expense, discomfort and risk to the patient since all instrumental examinations of the urinary tract involve risks, notably through the possibility of introducing new infections or stirring up latent ones.

**Significance of Symptoms.**—A chill or fever indicates probable infection. Unilateral pain in the back or abdomen may signify that the kidney or ureter is concerned. Sharp pain in these regions, especially when radiating to the bladder or testicles (ureteral colic), points to ureteral obstruction—most commonly calculus. Dull pain across the lower portion of the back may have its origin in the prostate or seminal vesicles. Suprapubic pain is frequently due to bladder or intestinal lesions, pain felt in the groins, testicles or perineum often originates in the genital organs. Frequency of urination is the most common symptom caused by disorders of the urinary tract and the most deserving of careful study. First a distinction must be made between frequent passage of small amounts of urine and frequent passage of large amounts (polyuria). The latter places the ailment in the "medical" category—diabetes, certain types of nephritis, ingestion of much fluid, emotional or neurological disorders, etc. Frequent urination of small amounts, however, is of concern to the surgeon. When the frequency is diurnal only, it points to an irritation about the trigone, bladder neck, the urethra

in women or the prostatic urethra in men this may be due to a stone or tumor but most commonly is a simple inflammation. When the frequency is noted both day and night it sometimes denotes a lesion of the spinal cord rarely a true contracted bladder and commonly a physiologically small bladder—there may be obstruction to the bladder outflow (usually in the prostate but sometimes due to urethral stricture) acute inflammation of the prostate or bladder tuberculosis of the kidney and ureter or some irritating substance medicinal or otherwise in the urine. In men over fifty prostatic obstruction is considered first while in young men tuberculosis or acute prostatic infection especially gonorrhea is suspected. *Burning or pain throughout urination* originates in the urethra pain only at the end of the act indicates a lesion at or near the outlet of the bladder. *Difficulty in starting the urinary flow* may be merely a nervous phenomenon or it may be due to an overfilled bladder or to an obstruction—most commonly prostatic a *small stream or dribbling* occurs most often with prostatic obstruction urethral stricture and neurological disorders. *Initial bleeding* originates in the urethra. *Terminal hematuria* points to the bladder outlet or prostatic urethra. *blood noted throughout the whole act of urination* may come from the kidneys ureters bladder or prostatic urethra.

**Collection of Urine**—Before the findings of urine analysis are interpreted it is of prime importance to know when and how the specimen was obtained. A freshly voided specimen is vastly more valuable than one that has stood chiefly because shreds may break up bacteria multiply red blood cells disintegrate and crystal and amorphous deposits form in old urine. If possible in examining urine in a surgical case a freshly voided specimen should always be used. It is a good plan to have the patient urinate successively in at least two glasses better three. The first specimen contains bladder urine plus the washings from the urethra if the urethra has been thus well irrigated the second glass contains bladder urine with rarely a cloud due to spermatozoa squeezed from the ejaculatory ducts by the muscular effort required to stop the flow of urine while changing from the first to the second

glass the third glass offers about as satisfactory a sample of bladder urine as one obtained by catheterization. Obviously the first glass will contain all the abnormalities of urine found in the bladder plus those gathered from the urethra (this specimen may be cloudy with pus due entirely to urethritis) while abnormal elements in the last glass most probably come from the kidney ureter or bladder but may have passed to the bladder from the posterior urethra because normally the internal urinary sphincter does not hold as tightly as the external. Neglect of such simple precautions too often leads to stupid deductions.

**Urine Examination**—While the first examination must always be complete interest largely centers on the albumin test and especially on the microscopic findings. Albumin may be found with pus from any source but is always present with appreciable amounts of blood. Pus from a kidney is apt to be associated with a more marked test for albumin than a similar amount of pus originating lower in the urinary tract. Pus casts (not frequently found) indicate a renal origin of pus otherwise the microscopic picture affords no clue to the source of either blood or pus. A few microscopists claim to be able to tell the origin of epithelial cells found in the urine but no experienced urologist should be influenced by such judgments in determining the source of accompanying pus or red blood cells.

**Physical Examination**—The urinary system must be regarded as merely a part of the complex body and its investigation conducted in that spirit. A thorough general physical examination should be made of every patient. Some disorder of the cardiovascular or pulmonary system (notably tuberculosis) or a lesion of the gastrointestinal tract may suggest the correct solution of a urinary problem. Moreover specific disease of other organs and the general condition of the patient are important factors influencing one's advice concerning the therapy to be applied to the urologic disorders discovered.

Particular attention is paid to the abdominal and genital organs. Enlarged or tender kidneys tenderness or masses over the ureter or bladder or a palpable or percuss

sible bladder will direct somewhat the later steps. Never must the digital examination of rectal mucosa, prostate, seminal vesicles and bladder be neglected and expressed secretion from the prostate should be routinely subjected to the microscope. Cancer, hypertrophy or infection of the prostate may readily account for blood or pus in the urine and for the symptoms.

**Minor Urologic Examinations**—Most patients with urinary disturbances particularly with frequency and especially in men past middle life should have the test for residual urine. After the patient has voluntarily urinated as much as he can a sterilized catheter is passed gently to the bladder under aseptic conditions and any remaining urine is collected and measured. If residual urine is found this is one of the most trustworthy evidences of prostatic obstruction but may indicate a diverticulum or deficient bladder function due to neurological disorders. Before the catheter is withdrawn the bladder capacity is measured by introducing a bland sterile solution. If a catheter will not pass or a stricture is otherwise suspected exploration of the urethra may be done at this stage with sounds and bougie à bouc and possibly filiforms. The silken bougie à bouc affords the most reliable means of diagnosing stricture—by feeling the constriction as the bulbous swelling at the end of the staff jumps by.

A roentgenogram is made if there is any indication of calculus and some surgeons include this simple painless procedure as part of a general routine. The roentgenographic exposures must always include the entire urinary tract. Often stones are found in unsuspected regions they may be symptomless but are potentially if not actually harmful. About 90 per cent of all urinary stones are of such chemical constitution that they can be demonstrated roentgenographically. If further special examinations are contemplated these simple roentgenograms should be made first as their disclosures will influence the subsequent procedures. The possibilities of diagnostic exploration with the urologist's special instrumentation are so great that all of them cannot be employed routinely. The maximum discomfort to the patient attends this part of the investigation hence the wis-

dom of gathering all the other relevant information first so that the greatest aid may be obtained from one special instrumental examination.

**Urethroscopy and Cystoscopy**—In the use of the following and indeed of all urethral instruments the utmost gentleness and regard for aseptic surgical technic are required.

The instruments used for the final localization and determination of obscure urinary diseases are possessed of visual and lighting properties and may roughly be grouped as *urethroscopes* (or endoscopes) and *cystoscopes* designed for inspection of the urethra and bladder respectively. The light is usually derived from a small electric bulb placed at the end which first enters the urethra or bladder. Vision is accomplished sometimes through an open tube but usually through a system of lenses arranged similarly to those in a microscope. Urethroscopes permit direct examination (and treatment) of the walls of the urethra; the detection of inflammatory lesions, stones, papillomas, etc. Their usefulness is particularly important in the diagnosis of lesions of the posterior urethra such as abnormalities of the verumontanum obstructing in trusions or prostatic lobes and sinuses from a ruptured abscess.

But the cystoscope opens up possibilities of diagnosis and treatment not only of lesions of the bladder but also those of the ureter and kidney. Modern cystoscopes consist of an outer sheath usually bearing the lighting system, a well fitted obturator used only during the passage of the sheath and interchangeable telescopes for use within the sheath. These may be for observation only, commonly at right angles to the long axis or this space may be given over only in part to the visual system allowing room for the passage of one larger or two smaller catheters, bougies, electrodes, forceps or other operative devices to be used under visual control.

By this means one may inspect the bladder mucosa noting inflammations, general or localized ulcers, tumors and calculi, diverticula or general trabeculations, the vesical outlet is studied for evidences of prostatic irregularities and protrusions from the normal contour, the trigone is carefully noted for

hypertrophy (due usually to great effort to open the sphincter muscle in the presence of certain types of prostatic obstruction) ulcers tubercles or neoplasms. The ureteral orifices demand especial attention—their size and shape whether they function normally whether the ejected fluid is clear cloudy or bloody whether indeed there are more than two openings. After the intra venous injection of certain dyes commonly indigocarmine one may gain important knowledge of the relative value of the kidneys by noting the time of appearance of the color at each orifice and the ultimate relative density of this color (meritoscropy or chromoscropy). But the most valuable information concerning each kidney is obtained by catheterizing both ureters and obtaining synchronously urine from the two sides. These are compared microscopically noting especially pus blood or bacteria and are examined for the amounts or percentages of any excretory product (usually urea) from the two kidneys. At the same time bacterial cultures are made directly from the urine obtained by catheters from the kidneys. The figures of urea percentages give some idea of the relative functional capacity of the two kidneys but another test is usually added for confirmation. Of the many possible ones the indigocarmine and phenolsulfonphthalein tests are commonly used the latter being preferred as it is easy to estimate the actual amount of dye excreted by each kidney in a definite period of time. (If the urea and color tests do not harmonize repetition of the cystoscopy may be necessary.) Thus it is possible to declare definitely whether one or both kidneys give signs of infection whether there is active bleeding from either (before catheters are passed) and roughly what their relative functional value is under existing conditions. But tests do not estimate the potential function of kidneys or indicate their capability under more favorable conditions. Through the ureteral catheters the capacity of the renal pelvis may be measured by injecting a bland fluid (normal saline) with little force pain may be deliberately caused in the kidneys so that the patient may voluntarily compare it in character and location with a symptomatic pain—sometimes a very valuable diagnostic aid. In normal cases

urine drops from ureteral catheters intermittently if a catheter is high enough to tip a dilated pelvis (hydronephrosis) or ureter there will be a continuous flow. If a ureteral calculus is suspected but not evident on the roentgen film it may be diagnosed by the passage up the ureter of a small catheter containing a bulb of wax near its tip. This wax will probably be scratched deeply and clearly as it passes the stone. Marks made on the wax by possible contact with the cystoscope are flat and superficial. To differentiate further the catheter is rotated on withdrawal thus making the calculus scratches spiral in form.

*Roentgenography and Cystoscopy Pyelograms and Ureterograms*—Still further information is obtained through the employment of cystoscopy and roentgenography combined. The location of shadows on the roentgen film near the line of the ureter may be accurately determined by taking a stereoscopic pair of films or a lateral film while a radiopaque catheter is in the ureter. A stone in the ureter will hug the catheter in films taken from all angles and in the stereoscopic pair will be clearly seen near the catheter and in the same lateral plane. Through the catheter the renal pelvis and ureter may be filled with a solution opaque to the roentgen rays and an outline of these cavities may be obtained on roentgenograms (called pyelograms and ureterograms). Of the many substances used in the development of this method sodium iodide has become universally popular. It gives good outlines is cheap and is relatively non-toxic and non-irritating. But it has been found that the newer materials developed for intravenous use (noted later) are even less irritating although more expensive. Thus are demonstrated dilatations constrictions irregular cavities (representing destructive processes) and filling defects. The latter are parts of the normal pelvic or ureteral lumens which should but do not contain any of the opaque fluid and which are evidently occupied by another substance such as a stone tumor or blood clot. These films will show the exact location of renal stones already demonstrated on earlier films whether in the pelvis or calices and will sometimes indicate the smaller percentages of stones which are not visible on simple roentgen

films as filling defects. By this method characteristic visual evidence is obtained of hydronephrosis, polycystic kidneys, cysts and neoplasms, certain congenital deformities such as double pelvis and ureters, non-rotated kidney and horse shoe kidney are clearly demonstrated. Incomplete filling of the pelvis and calices may cause erroneous deductions. If air is carelessly injected a false filling defect will appear. In cases in which the outline of the kidney is not clear the exact location of the organ and its size are depicted. The mobility is determined by making exposures with the patient first reclining and then upright.

**Cystograms and Urethrograms**—By injecting into the bladder through a catheter a fluid opaque to roentgen rays an outline of the vesical cavity (cystogram) is obtained which shows irregularities of the contour or filling defects caused by new growths, blood clots or large stones in the bladder, pressure by masses from without, diverticula, trabeculation, local absence of distensibility (scar), etc. Similarly the urethra may be filled and its outline portrayed—this has been found useful in studying prostatic encroachment on the urethra and bladder lumen; the rare urethral diverticula and other irregularities.

**Intravenous or Excretory Urograms**—A great advance has been made as a result of the laboratory synthesis of compounds containing much iodine which are not too disturbing when given intravenously and which when excreted by the kidneys fill the urinary tract with a fluid opaque to the roentgen rays. Iopax and neoiofax, skiodan and neoskiodan are the trade names of materials in common use. Now good reports are made concerning other substances which may be given by mouth and are excreted by the kidney in sufficient concentration to allow satisfactory urograms to be made in many cases.

Thus the whole collecting part of the urinary tract can be outlined on a roentgenogram. The entire lumen from kidney to urethra or a part of it is outlined roentgenographically; is called a urogram. The intravenous method which gives satisfactory outlines in many cases affords also something of a test of renal function as only a relatively good kidney is capable of excret-

ing within five minutes the substance introduced intravenously.

The intravenous or secretory method of making urograms and the catheter or retrograde method have some values in common and each has individual advantages so that it seems that one will never entirely replace the other. Their relative values and the indications for their use clinically cannot be discussed here.

**Renal Function Tests**—The commonly employed methods of comparing the functional ability of the two kidneys have been briefly described but it is of much more value in most urologic work and of fundamental importance always to know the total renal function of a patient. Many tests affording some indication of this have been devised and many discarded. Only those in popular use today can be referred to here. Certain non-protein constituents of the blood are estimated most frequently the total non-protein nitrogen, urea nitrogen and creatinin; their normal values are from 30 to 40, 10 to 15, 0.5 to 1.5 mg. per 100 cc. of blood respectively; the specimen being obtained before the patient has partaken of food in the morning. Figures above those given indicate a retention of waste products and generally a corresponding renal deficiency. The urea clearance test of Van Slyke is probably the most valuable indicator of renal function but in practice most urologists feel that this method is too exacting for frequent repetition. Another group of tests depends on the ingestion or injection of various substances normally found in the body or entirely foreign and the determination of the amount of each the kidneys can excrete in a given time. Experience has shown the practical value and simplicity of such tests done with foreign substances especially dyestuffs and the estimation of the output is simple. Phenolsulfonphthalein is pre-eminently popular. 0.6 Gm. is injected intravenously; the time of appearance is noted or arbitrarily called five minutes and collections are made during four subsequent half-hour periods. Quarter-hour periods give a more correct view but this is impracticable for various reasons. A normal pair of kidneys will excrete 50 per cent of the dye injected in the first half hour with rapidly decreasing amounts in the succeeding pe-



riods. Smaller amounts in the earlier periods with equal or larger amounts later indicate a poorer degree of function. The details of this and other renal function tests and their practical application must be sought for in larger works.

ALEXANDER R. STEVENS

### CONGENITAL ANOMALIES OF THE GENITOURINARY TRACT

Congenital anomalies are fairly common in the genitourinary tract, being more frequently encountered in the urinary tract than in the genital tract. Since the urinary tract is hidden, the diagnosis of these anomalies can be made only at autopsy or at

### ANOMALIES OF THE KIDNEY

For purposes of discussion the anomalies of the kidney may be grouped according to the number, form, position, structure, and blood supply. The anomalies of the ureters are closely associated with those of the kidneys.

**A Anomalies of Number—1 Bilateral absence** of the kidneys is incompatible with life but has been reported (Price and Murless).

**2 Unilateral absence**—Complete absence of one kidney is true agenesis and is the result of complete failure of development of the ureteral bud. Associated with this condition is complete absence of the ureter and the ureteral orifice. This condition should

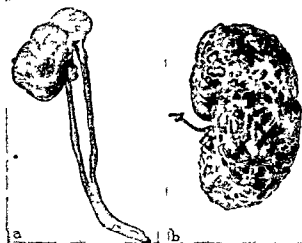


Fig 644—*a* Gross specimen (removed at operation) of a fused supernumerary kidney with complete duplication of the ureters to within 3 cm. of the bladder where they fused to form one opening into the bladder. *b* gross specimen of polycystic kidney (removed at operation). Hematuria and marked infection made operative imperative. The patient lived for two years.

operation or by cystoscopic and roentgenographic studies. Before any surgical procedure on the urinary tract is carried out it is of utmost importance first to establish whether or not an anomalous condition is present.

Surgical correction of many of the anomalies of the genitourinary tract is not only possible but urgently desirable. Sometimes several painstaking operations may be required to correct one condition. An operation for the correction of an anomalous condition of the genital tract should be carried out when possible before the patient reaches ten years of age.

Anomalies of the urinary tract and of the genital tract are commonly associated.

not be confused with a fusion anomaly in which one kidney has fused with the opposite one. In some cases in which the ureteral bud has partly developed there will be a ureteral orifice with a ureter that ends blindly but no kidney. These are not cases of true agenesis.

A single kidney is more frequently found in the male and is usually on the left side. An incidence of 1 case in 2000 autopsies is reported by various observers. Goldstein has reviewed the literature on congenital absence of one kidney. Collins recently reported an incidence of 1 in each 700 cases in a series of 6349 consecutive autopsies.

When there is complete congenital absence of one kidney there is always resul

tant compensatory hypertrophy of the other kidney with enlargement of the renal pelvis and calices. This enlargement of the pelvis and calices is not present in cases of required compensatory hypertrophy of the kidney.

A single kidney becomes of clinical importance only when it is the seat of a pathologic condition. It is subject to some type of pathologic condition in 40 or 50 per cent of

3. *Supernumerary kidney* may be unilateral or bilateral. They may be free or fused. A free supernumerary kidney is entirely free from the kidney on the same side, a normal kidney being present on the opposite side. The supernumerary kidney is usually at a lower level than the normal one and is somewhat irregular in outline as well as smaller. A free supernumerary kidney is probably the rarest of congenital anomalies.

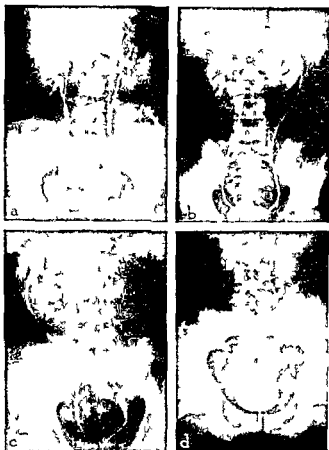


Fig. 61.—a Pyeloureterogram of bilateral supernumerary fused kidneys with complete reduplication of the ureters. b bilateral ureteropyelogram of a horseshoe kidney verified at operation. A stone was removed from the left kidney. The calices point medially on the left but downward on the right. c bilateral ureteropyelogram of congenital crossed dystopia. There is a stone in the dystopic kidney. d cystogram of a congenital diverticulum of the bladder. The small shadow is the diverticulum. It was removed at operation.

cases. Associated with this anomaly malformations of the genital organs are found in about 75 per cent of cases. Some of the anomalies that are found are uterus bilocularis, uterus unicornis and pseudohermaphroditism. Surgical treatment of a congenital single kidney is far more hazardous than surgical treatment of a kidney when both kidneys are present. Burrell has reported a case of unilateral congenital renal agenesis with tumor.

In 1937 Geisinger found reports of 40 cases including 2 of his own.

A fused supernumerary kidney or double kidney, as it is frequently called, is more common than the free type. The bilateral occurrence of the condition is less frequent than the unilateral (Goldstein and Shaw). In this condition the upper kidney is less developed than the lower one. From its size and contour the upper kidney appears to be the supernumerary one and is frequently

rudimentary Triple kidneys are very rare but have been observed (Hanley)

A *rudimentary kidney* in itself occurs only occasionally

The anomalies just described are of extreme clinical importance particularly when operation is contemplated Supernumerary or double kidneys are frequently the site of pathologic conditions All types of renal disorders such as hydronephrosis pyelonephrosis tuberculosis calculi pyelonephritis neoplasm and polycystic degeneration of the kidney have been encountered in the supernumerary structure The diagnosis of the condition is made by cystoscopy and pyelography by either the retrograde or the intravenous method

**B Anomalies of Form**—1 *A horseshoe kidney* occurs about once in every 1000 cases In this type of anomaly the union takes place across the midline in the region of the lower poles of the kidneys and ventral to the aorta and renal cava Occasionally the union is posterior to the vessels the union may also take place in the upper poles of the kidneys The result of the common form of fusion presents a semicircular mass with two ureters and vessels coming off from the ventral or mesial aspect of the kidneys The union is known as the isthmus and consists of either connective or renal tissue According to Gutierrez the patient has a horseshoe kidney syndrome which is characterized by pain in the umbilical or epigastric region gastrointestinal disorders and intermittent attacks of urinary disturbances According to Botez in about 16 per cent of the cases the kidneys undergo pathologic changes and only then do they give rise to symptoms The type of pathologic condition found is principally hydronephrosis but calculi tuberculosis pyelonephritis and neoplasms have been described in some of the cases of horseshoe kidney (Goldstein) The diagnosis of this condition is all ways possible before operation

2 Other uncommon fusion anomalies such as disk kidney sigmoid kidney or lump kidney have been described

3 *Kidneys with Supernumerary Calices*—On rare occasions extra calices are seen entering the renal parenchyma from the outside Eisendrath collected reports of 3 cases and described a case of his own

**C Anomalies of Position**—A kidney that has never occupied a normal position but is lower is known as an *ectopic kidney* When an ectopic kidney is on the proper side it is said to be *dystopic* when it is on the opposite side there is said to be *crossed dystopia* The kidneys may not be fused (Beer and Ferber) The ureter usually goes to the proper side but is short because during embryonic life it did not lengthen normally and therefore the kidney did not ascend to its proper place The renal vessels arise from the nearest vessels usually the common external or internal iliac arteries Bilateral renal ectopia occurs seldom (King Morgan and Stone)

**D Anomalies of Structure**—1 *Congenital hypertrophy* has been observed in cases of congenital absence or congenital atrophy of one kidney The size and functional capacity of the normal kidney are increased The pelvis is larger and there is an increase in the number and size of the glomeruli and tubules

2 *Congenital Hypoplasia*—When the renal parenchyma of the columns of Bertin fails to develop to its full extent there is a resultant small not fully developed kidney known as a hypoplastic kidney Such a kidney is frequently predisposed to disease

3 *Aplastic Kidney*—Congenital aplastic kidney is just another name for hypoplastic kidney There may be lack of development of the kidney or degenerative changes may have taken place during its development Cysts and fetal lobulations as in an atrophic kidney are usually not observed Symptoms are present only when pathologic changes have occurred

4 *An atrophic kidney* is the remnant of an undeveloped kidney and ureter on the side opposite a congenital single kidney The diagnosis is made by means of the pyelogram and is of extreme importance clinically if surgical treatment is contemplated for the normally developed kidney The remaining parenchymal tissue usually is not normal therefore a relative functional test demonstrates a delayed appearance time and total reduction of function This is not true of a hypoplastic or aplastic kidney for which the appearance time is normal but there is demonstrated a decreased total output Cystic degeneration is usually present

**5 Congenital Cystic or Polycystic Kidney**—The theory of the double formation of the tubules is believed by Hildebrandt to be the cause of polycystic kidney. He believes that the cystic condition is due to the failure of union between the collecting tubules and the metanephrogenic Anlage. With the beginning of the secretion of the glomerulus there is no outlet because of non union hence a cyst forms. The condition is observed about once in every 500 autopsies. With present day methods of diagnosis the condition is observed more frequently and earlier than formerly. The condition may be recognized in infants and children today because of the better means of diagnosis. The condition is usually diagnosed in patients between the fourth and fifth decades of life. There are some hereditary and familial tendencies.

A study of the urine and blood and pyelography make the diagnosis definite. The specific gravity of the urine is low and a trace of albumin and occasional blood cells are the usual findings in the urine. The low pHthalein output and the high urea content are fairly constant features. The elongation of the pelvis and calices without dilatation of these structures is significant. The cause of death in over 50 per cent of the cases is uremia. It is interesting that neither medical nor surgical treatment offers a great deal of relief except in the unusual case. Removal is contraindicated except when an emergency arises such as hemorrhage or severe infection in one of the polycystic kidneys (Goldstein and Klotz) but puncture of the cysts the removal of some or the production of a cutaneous renal fistula offers some relief at times. In 4 cases in which the writer operated a temporary nephrocutaneous fistulous tract was produced on both sides and gave remarkable relief (Goldstein).

**E Anomalies of Renal Vessels**—Numerous reports of various dissections of series of anatomic specimens have demonstrated that in 56 per cent of the cases there is more than one renal artery and vein. As many as four separate ones have been found on each side. These accessory vessels usually enter the poles of the kidney the upper pole being the more frequent site. The vessels originate in most instances from the aorta but may arise from other large vessels.

These anomalies in the blood supply are of considerable surgical importance particularly in the production of obstruction when the anomalous vessel crosses the ureter.

### ANOMALIES OF THE URETERS

There may be complete absence of the ureters on both sides complete absence or atrophy on one side complete duplication on one or both sides or incomplete duplication on one or both sides. Such a condition is most frequently associated with an anomalous condition of the kidney. When an extra ureter is present with an extra pelvis it is observed that the upper portion of the pelvis is drained by the ureter which has the lower ureteral opening in the bladder. Three ureters on one side have been reported (Haney Miller). The diagnosis is made entirely by means of the cystoscope the ureteral catheter and roentgenograms made after an opaque solution has been either injected through a ureteral catheter or given intravenously. Bilateral complete or incomplete duplication of the ureters is the least common of all the conditions found (Goldstein and Shaw).

Occasionally an accessory ureter may be present on one side with an extra intravesical ureteral orifice but without a double pelvis. In these cases the ureter ends blindly in its upper portion (Hinman).

The ureter as well as the kidney frequently may assume an unusual position. In crossed dystopia the ureter crosses the midline. If more than one ureter is found in the lower portion usually each has a ureteral orifice of its own. The ureter may also assume a post-cervical position (Shih). The ureteral orifice may be strictured or stenosed. The ureter may be small or dilated above the stricture resulting either in an atrophic or a hydro-nephrotic kidney. In most cases the stricture occurs close to the bladder.

A cyst of the ureter may occur and may be the result of stricture. It may be either intravesical or extravescical. In the intravesical type a marked bulging appears in the bladder. Owing to underdevelopment the ureteral orifice frequently terminates in some organ other than the bladder (Crenshaw and Buchtel) such as the vas deferens seminal vesicle ejaculatory duct prostatic utricle or urethra in the male in the vestibule of the

vagina Gartner's canal uterus or fallopian tube in the female or in the rectum

### ANOMALIES OF THE BLADDER

*Complete absence of the bladder* has been reported. *Double bladder* has been reported by Cathelin and Sempe. A septum may lie in the frontal plane dividing the bladder into an anterior and a posterior compartment or it may lie in the sagittal plane making a right and a left bladder. About 20 cases in which there were two *multilocular bladders* have been reported. These cases as well as those in which there is a septum are not cases of true double bladder. Cases of true double bladder are usually associated with a double penis or with anomalies of the penis and urethra. Cases that are reported of double bladder should not be confused with cases of diverticular bladder which may also be found as an embryological defect (See section on Diverticulum of the Bladder). Definite diagnosis of these conditions can be made by cystoscopic and roentgenographic examination.

The *urachus* which is the remains of the cord running from the apex of the bladder to the umbilicus may be patent either in full or in part. When it remains fully patent there is discharge of urine from the umbilicus. If it is only partially patent a urachal cyst may form.

A patent urachus or a urachal cyst is of clinical significance only when it causes symptoms. As a rule no symptoms are present unless the structures become infected.

*Exstrophy of the bladder* is fortunately a rather infrequent condition occurring about once in 30 000 cases. It is most likely the result of defective embryological development and the anterior portion of the bladder and lower portion of the abdominal wall are missing. When this particular region of the abdomen is exposed for examination the floor of the bladder the mucosa of which is thrown into many folds and its trigone are seen. In most instances the ureteral orifices can be found. In cases of complete exstrophy there is wide separation of the pelvic bones with absence of the symphysis pubis. The penis is small the urethra is epispadiac and incomplete and the scrotum is small. The verumontanum and the ejaculatory ducts are often observed on the floor of the

urethra. The prostate and seminal vesicles are either atrophic or absent. Other anomalies may be associated with this condition such as spina bifida and the presentation of an open intestinal tract on the abdomen. It occurs about eight times more frequently in males. When it is seen in the female the urethra is open from above and hypospadias is present.

### ANOMALIES OF THE URETHRA

Absence of the urethra when the penis is present is rare. Reports of only 7 cases having been collected by Kaufmann. When this condition occurs it means that there was failure of the urethralanlage to develop. The production of a solid cord in place of the urethra once it has been formed is also an anomaly which has been reported.

**1 Supernumerary Urethras or Urethral Canals**—In this anomaly the duplication may be partial or complete and may be situated either dorsally or ventrally. When it is partial the canal usually runs for a short distance from the external meatus being termed an accessory urethra. If the duct runs into the bladder then a true double urethra is present. An anomalous urethra may be associated with a supernumerary penis, vagina or rectum. Diphallus or duplication of the male external genitalia in whole or part is a relatively uncommon disturbance of development. Nesbit and Bromie in a search of the literature found only 45 cases reported in a span of nearly three hundred and twenty five years. In 6 of these cases a double bladder was found but there was no demonstrable connection between the two bladders. A splitting of the vesicourethralanlage is in all probability the embryological etiologic factor as in the case of a double bladder.

**2 Paraurethral Ducts**—Paraurethral ducts are not supposed to have the same embryological development as accessory urethras. They are observed around the external meatus are small and frequently are associated with other embryological defects of the penis and urethra such as hypospadias. In many instances they end blindly but in others they connect with the urethra after they have run a short course of 3 to 10 mm.

**3 Congenital Obstructions of the Urethra**—Complete obliteration of the urethra

occurs rarely. The most common form of occlusion occurs at the external meatus frequently in association with phimosis. The most important type of congenital obstruction of the urethra is caused by congenital valves. These are limited to the posterior portion of the urethra usually in close relation to the verumontanum. Three types occur: (1) distal, (2) proximal and (3) superior to the verumontanum. They are comprised principally of folds of mucosa of the urethra causing urinary obstruction with subsequent dilatation of all structures behind the valves. The treatment consists principally of removal of the obstruction by dilatation or excision of the valves. Davidohn and Newberger have reported on congenital valves of the prostatic urethra and state that the number of cases reported reaches nearly 100. They describe an unusual anomaly of identical congenital valves of the prostatic urethra in twins.

**4 Diverticula and Cysts of the Urethra**—Diverticula are more common in the pendulous portion of the urethra. Cysts of the urethra occur as a result of the occlusion of one or the other duct of Cowper's glands.

**5 Hypospadias**—In this condition there is malformation of the penis and urethra. The external meatus is located at some point proximal to its normal situation but always on the ventral wall of the urethra. According to Young the meatus may be glandular, penile (Fig 646), penoserotol, serotol, perineal or pseudovaginal.

Hypospadias is the most frequent anomaly of the urethra. Young says the incidence is about 1 in every 160 but the writer has found it less frequently. Embryologically it is due simply to an arrest in the development of the urethra. Associated with this defect is the condition known as congenital chloredie which is found principally in the severe grades of the malformation. The symptoms depend on the degree of malformation and there may be no symptoms except with regard to the direction of the stream. The sphincters of the urethra are not involved in these cases.

**6 Epispadias**—In this malformation the urethral orifice is found dorsal to its normal position. It may occur in either sex and is frequently associated with ectrophy of the

bladder. Young divides them into the glandular penile and complete epispadias in the male and the clitoric subcymphyseal and complete in the female. The condition is less common than hypospadias occurring approximately once in 1000 cases. The condition is less common in the female. The sphincters of the urethra are involved causing either partial or complete incontinence of urine. On account of the abnormal curvature produced coitus is impossible.

## ANOMALIES OF THE TESTIS

This organ is developed on the anteromedial surface of the wolffian body. From the wolffian duct the vas deferens is developed and from a small offshoot of the wolffian



Fig 646—Hypospadias (penile type). The arrow points to the orifice. The condition was corrected by operation.

duct the seminal vesicle and ejaculatory duct are formed.

**1 Anorchidism, Monorchidism, Polyorchidism and Synorchidism**—Absence of a testicle is rare and is the anomaly least frequently encountered. Bilateral absence of the testicles has been reported by Counseller and Walker and by Fleet. Meyer reported in 1927 on 23 cases of absence of one testis. Cases of absence of the epididymis, the vas deferens, the seminal vesicle and the ejaculatory duct have been reported but complete absence of all four structures has never been noted. The presence of an extra testicle has been noted by Jordan and Dodson, who also reported cases of other authors.

Synorchidism is a fusion of both testicles within the abdominal cavity—a rare anomaly.

Ectopia of a testicle has been reported by Campbell and by Muschat. They have encountered a testicle in the perineal position. 2 **Hypertrophy and Atrophy of the Testis**—True congenital hypertrophy of a testis has been reported by Fernandez. Congenital atrophy of the testis occurs occasionally and is due to a defect of formation during fetal life.

### HYDROCELE

When the cavity between the tunica vaginalis and the abdominal cavity remains open, *congenital hydrocele of the tunica vaginalis* results. The same incomplete closure of the peritoneovaginal process may occur somewhere along the cord and then *hydrocele of the cord* results.

The diagnosis of hydrocele is readily made. The hydrocele of the tunica vaginalis may or may not communicate with the peritoneal cavity. In the latter event the fluid content may be forced into the peritoneal cavity by compression of the hydrocele. Noncommunicating hydrocele of the tunica vaginalis and hydrocele of the cord have a firm fluid consistency and may be transilluminated. They may grow to large size and become thick walled.

The treatment of hydrocele is surgical. Injection of irritants to obliterate the cavity has proved to be unsuccessful. Either excision of the sac wall or the 'bottle operation' is advisable. In the latter the upper part of the sac is incised and the sac is then turned inside out; a few sutures anchoring it in this position. If the hydrocele communicates with the peritoneal cavity, hernio-plasty is necessary.

### PSEUDHERMAPHRODITISM AND HERMAPHRODITISM

those of either sex. The author recently encountered a patient who came to operation a girl of 14 with hirsutism. There was a well developed penis measuring 4.5 cm. in length and a well developed vagina. All the internal female organs were normal. The urethra opened into the vagina. No adrenal tumor was present nor were testes present.

### UTRICLE SEMINAL VESICLE AND VAS DEFERENS

In pseudohermaphroditism anomalous conditions of the prostatic utricle are frequently found. In the male the müllerian duct which should undergo degeneration does not do so and then there may be the formation of female organs. Anomalous tube-like structures may also form from the müllerian duct and from part of the spermatic cord or a cyst along the cord. The seminal vesicle, ampulla and vas may be absent even when the testicle on the same side is present and normal. If a testicle is present with its epididymis, then a vesicle and vas are usually present. The vas practically always runs to the testis of the same side.

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of the kidney. In this condition the infection is originally limited to minute areas of focal suppuration in the renal cortex widely disseminated but not extending to the medulla or pelvis.

5 *Pyelonephritis perinephric abscess* and *paranephritis* describe the somewhat variable group of pathologic changes resulting from infection around the kidney but primarily external to the true renal capsule.

The above terms are both pathologic and clinical descriptions of renal disease but as is apparent from their definition may be rather loosely applied in clinical work. They frequently occur simultaneously or overlap in their extent of involvement.

**Routes of Infection**—Bacteria reach the kidney (and ureter and bladder) by four main routes:

A *Hematogenous* (blood borne)

B *Lymphogenous* (through the lymphatic channels)

C *Ascending* (a) Through the lumen of the ureter from the bladder below (b) along the sheath of the ureter or (c) by way of the ureteral lymphatics (as in 2)

D *By contiguous or direct suppuration*

A *Hematogenous Route*—The transfer of bacteria to the kidney through the blood stream seems most common in ordinary practice. By this route organisms are absorbed and carried to the kidney from the tonsils, apices of teeth, throat, nasal sinuses, middle ear, appendix, gallbladder, fallopian tubes, alimentary tract, endocervix and cutaneous lesions. Bacteria are not excreted by the normal kidney but only pass out in the urine as a result of an infectious lesion in the urinary tract. The kidney, contrary to past teaching, can no longer be regarded as a simple filter for bacteria carried to it from other parts of the body. One or both kidneys may become infected from a blood borne source.

B *Lymphogenous Route*—There are two possible routes by which infection through lymphatic channels can reach the kidney.

1 *From the Lymphatics of the Colon to the Perirenal Lymphatics and from These to the Kidney*—This pathway is said to infect the right kidney more frequently because of direct lymphatic distribution from the right half of the colon. Clinically it seems to be the route in some instances of renal infection secondary to ulcerative colitis and

## INFECTIONS OF THE URINARY TRACT

Bacteria reach the urinary tract from some infective source in another part of the body or by ascent through the urethral lumen. Infection in the kidney, ureter and bladder is therefore always secondary to a systemic focus or to urethritis.

## NON TUBERCULOUS INFECTIONS OF THE KIDNEY

**Kinds of Infection**—In the order of frequency of occurrence the kinds of infection are as follows:

1 *Pyelitis* (or *pyelonephritis*) implies infection in the walls of the renal pelvis, calices and portions of the parenchyma of the kidney usually limited to the pyramidal region.

2 *Pyonephrosis* implies massive infection of the renal parenchyma and calices with gross pathologic destruction of tissue. This condition is frequently the result of or accompanies obstruction to the free outflow of urine from the kidney or ureter.

3 *Infected hydronephrosis* implies pyelitis in a dilated renal pelvis and calices but without suppurative destruction of renal tissue.

4 *Cortical infection* (abscess) is sometimes called acute hematogenous infection



acute inflammatory conditions of the bowel, such as follows ptomaine poisoning and acute dysentery. It is claimed to be the pathway in the tropics, where dysentery is so frequently followed by urinary infection.

2. *By Way of the Lymphatics of the Ureteral Wall and Perureteral Sheath.*—This is probably an uncommon route but may carry bacteria from the male and female urethra

ureter and thence to the kidney. This is apparently the route in certain instances in which there is residual urine in the bladder and in which bacteria gain entrance through catheterization or instrumentation or following surgical operations on the bladder or its outlet. It is possibly the route in some of the renal infections in girls and in women with urethritis or gaping urethra.

### SOURCES OF URINARY INFECTION

Primary foci of infection and contributing intrinsic causes and results in urinary tract.

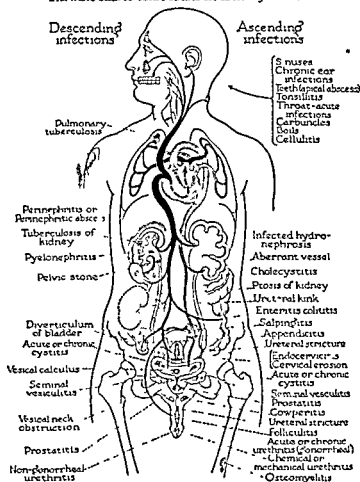


Fig 617—Sources of urinary infection

and bladder, the female pelvic organs and the prostate and seminal vesicles to the kidney.

C. *Ascending, or Urogenous, Route.*—This presumes that the bladder has become primarily infected from below, without prior renal infection, and that the bacteria are carried up through the lumen of the ureter to the renal pelvis. This mode of infection is the result of regurgitation or reflux of a small portion of the bladder content into the

D. *Contiguous or Direct Infection.*—Infection may be carried by extension through tissues adjacent to the urinary tract, as in subphrenic abscess, diverticulitis, retrocecal appendicitis or direct perforation into the urinary tract by similar suppurative conditions.

Causative Organisms.—In non tuberculous infections of the urinary tract the common infecting organism may be either (1) bacillary or (2) coccal.

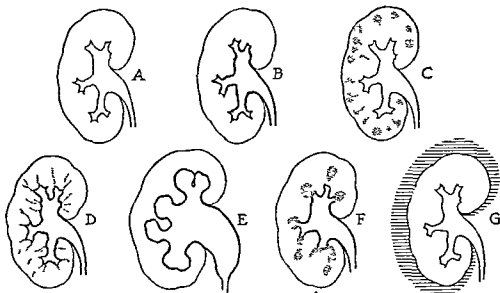
1. *BACILLARY.*—In about 70 per cent of patients

seen in general practice the organisms responsible for infections of the kidney and bladder belong to the so-called colon typhoid group. These are gram negative and may be of the hemolyzing or non hemolyzing type the latter being more common. While there have been more than 70 strains of *Bacterium coli* isolated the tendency in clinical work is to classify these in two main groups (a) *Escherichia coli* (b) *Bacillus coli aerogenes*. This latter classification is considered important from the point of view of treatment which will be considered later.

*Bacterium typhosus* is the causative agent in secondary infections of the kidney and bladder occurring during typhoid fever. The comparative rarity of this disease naturally makes typhoid an increasingly uncommon

*Pneumococcus* infection occurs rarely. The *gonococcus* (gram negative) has been identified as the cause of infection of the upper urinary tract in less than 100 cases reported in all the world's literature. This latter fact is emphasized to controvert an impression among medical students and some practitioners that gonococcal infection of the kidney is a common condition.

The degree and persistence of bacterial infection in the urinary tract therefore depend on (1) the virulence and character of the infecting organisms (2) the continued activity of the primary focus of infection (3) the presence of causes in the urinary organs themselves which interfere with the normal escape of urine (obstruction or atony) and (4) the patient's resistance (factors of immunity) to the specific organisms present.



A-Normal, B-Pyelitis, C-Cortical abscesses, D-Diffuse pyelonephritis, E-Infected hydronephrosis, F-Pyonephrosis, G-Perinephric abscess

Fig. 618—Diagram showing various types of renal infections

form of urinary infection. Cases of typhoid pyelitis are occasionally reported without evidence of demonstrable infection of the intestinal tract or the gallbladder.

*Bacillus proteus* and allied organisms which split urea from the urine and favor precipitation of alkaline salts may be the sole invaders of the urinary tract or they may occur with the *B. coli* group.

*B. pyocyaneus* and other gram-negative bacilli are uncommonly present in pure culture as the cause of urinary infection.

**COCCAL.**—Next in frequency to the colon bacillus the causative organisms in the etiology of renal and vesical infection are the gram-positive cocci. *Staphylococcus albus* and *aureus* are most common and *streptococci* are less common. Hemolyzing streptococci most frequently cause acute cortical infection of the kidney, a serious lesion fortunately not common. Non-hemolyzing streptococci may exist alone as the cause of renal infection but more often are associated with *Bacterium coli*.

**Pathology.**—It will be easier to understand the changes which take place in renal infections if they are considered as clinically acute and chronic.

**Acute pyelonephritis** is usually a bilateral condition but may be limited to one kidney in fulminating infections of the blood stream. In the early stages on gross inspection the entire surface of the kidney reveals the presence of innumerable minute hemorrhagic areas. On section a few areas are visible in the parenchyma, but the surface epithelium of the pelvis is densely underlain with larger areas of hemorrhage. This local reaction may progress and at a later stage the hemorrhagic areas may be occupied by various sized soft yellow abscesses. Micro-

scopically the punctate hemorrhagic areas correspond to bacterial emboli which fill the capillary loops glomeruli or tubules. The changes in the pelvis are less marked in acute pyelonephritis than in the chronic forms. The mucosa is swollen and red with varying areas of ecchyma. There is edema and thickening of the walls of the pelvis and surrounding peripelvic and periureteral tissues. Massive localization may give rise to cortical abscesses or a carbuncle of the kidney.

**B Chronic pyelonephritis** shows pathologic lesions of varying type and degree. The changes may predominate in the parenchyma or in the pelvis or may present in equal involvement of parenchyma and pelvis. When the parenchyma is chiefly involved there is a circumscribed or diffuse fibrosis scattered irregularly throughout the renal substance. These changes may result in atrophy of the kidney, perirenal adhesions, thickened perirenal fat, thickened rigid pelvis and ureteral walls and diffuse areas of scar tissue in the renal cortex.

When pelvic changes predominate the walls of the pelvis and calices become thickened and fibrotic with resultant dilatation and rigidity. Minute nodules of circumscribed lymphoid infiltration (granular pyelitis), minute retention cysts (pyelitis cystica) or metaplasia of the epithelial lining with skin like replacement of the epithelium (leukoplakia) may result.

When changes of equal intensity occur in the pelvis and the parenchyma (this constitutes the majority of cases of chronic pyelonephritis) there may be added to dilatation of the pelvis and its calices a compression atrophy of the parenchyma. If localized areas of destruction occur multiple cavities containing pus may be found in the renal substance (pyonephrosis).

All phases of these changes may be found depending on the severity and virulence of the infection, the presence of obstruction to the free outflow of urine and the duration of the reaction.

**Clinical Picture of Pyelonephritis**—In general despite age or sex the clinical picture of renal infections may best be classified as (1) *without signs or symptoms localized to the urinary tract* or (2) *with signs and symptoms pointing to the urinary tract as the source of infection*.

### I Cases without localizing signs

**A Acute fulminant infection with high fever** is often preceded by a chill, sudden elevation of temperature, rapid pulse, stupor and marked toxemia. There may be associated nausea, vomiting and anorexia. No frequency or disturbance in urination and no rigidity or tenderness in the lumbar region or on renal palpation is noted. There is variable although usually moderate elevation of the leukocyte count. A moderate amount of pus is found in the urine usually with a definite trace of serum or nuclealbumin and bacteria (often cocci) on urine culture. Occasionally pus may be absent from the urine in the early stages. Such a clinical picture often occurs in children and in pregnancy and the puerperium and may give rise to the erroneous diagnosis of gastroenteritis, peritonitis, influenza, typhoid, etc.

**B Acute febrile reaction of less severity** may be characterized by a sudden onset with or without preceding chill, moderate elevation of temperature with frequent and marked remissions but no particular evidence of stupor or toxemia. No reflex gastrointestinal symptoms are present and only slight if any leukocytosis. A moderate number of pus cells and bacteria are found in the urine. No renal or lumbar pain is felt and there is no frequency or disturbance of urination.

At the onset the diagnosis can be made only by exclusion and on the faintly suggestive urinary findings. If the urinary infection does not subside rapidly in a case belonging to group A or B localizing symptoms frequently develop after a day or two and pain in the lumbar region, frequent or painful urination and an increase in pus and bacteria in the urine suggest definitely the presence of infection in the urinary tract.

**C Subacute or Chronic Pyelonephritis Without Localizing Signs Pointing to the Kidney**—In this group of cases which is very large the initial symptoms are those of infection in the bladder or urethra but there are no symptoms pointing to the kidney. Bladder disturbance is the initial symptom of renal infection in 50 per cent of cases. The central symptom is frequency of urination with pain or burning during voiding. In the male urethral discharge and pain in the urethra and perineum may precede the bladder

symptoms and yet be entirely secondary to acute renal infection. Systemic symptoms in this group vary widely from febrile to afebrile and from great bladder discomfort to mild annoyance on urination.

*Silent pyuria* is a term given to a condition in which there is a marked amount of pus and bacteria in the urine from renal and vesical infection and yet the patient has no other local or systemic symptom of disease.

**2 Cases with Localizing Signs**—A. *In acute febrile onset* frequently preceded by a chill, sudden elevation of temperature, weak rapid pulse and signs of acute infection plus pain in the costovertebral and lumbar region, rigidity of the erector spinae and upper abdominal muscles and an enlarged tender palpable kidney are characteristic. There is an increased leukocyte count and pus is present in variable quantity in the urine. Symptoms of bladder disturbance may or may not accompany the onset. The temperature may remain elevated or may rapidly become intermittent in type.

B. *Subacute or chronic type with localizing signs* is usually preceded by frequent or painful urination, notable pyuria or hematuria with pain in one or both lumbar regions. The onset is not associated with noticeable chills or fever or any toxic systemic reaction. The urinary findings include albumin, pus, blood and bacteria.

**Diagnosis**—All persons suffering from urinary infection may present combinations of these symptoms. A positive diagnosis is made only by finding bacteria and pus in the urine. A complete physical examination is necessary with exclusion of pulmonary or intra-abdominal lesions plus evaluation of the renal or vesical signs of infection. These must be confirmed by positive urine cultures and the findings of pus, blood and epithelial debris in the urine. One must especially consider the urinary tract as possibly infected whenever fever and other symptoms of generalized toxemia are prominent without localizing signs.

**Differential Diagnosis**—Since urinary infections are secondary to infection elsewhere in the body, it is well to remember that co-existing prior infection may mask or in turn be masked by the primary complaint. Appendicitis, salpingitis and pneumonia are frequently forerunners of secondary renal

infection and the proper evaluation of the severity of each condition must be made.

In general the respiratory infections such as influenza, bronchopneumonia and pneumonia must be differentiated from acute renal infection. Subacute cholangitis, enteritis, pelvic inflammatory conditions, malaria and typhoid fever must be differentiated in more obscure cases. The most important consideration in cases with localizing symptoms is the recognition of renal or perinephritic

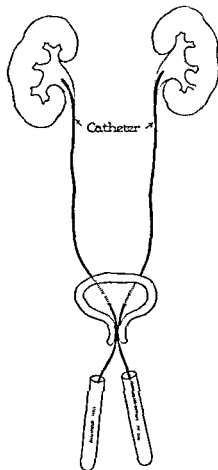


Fig. 649.—Diagram of a new method of collecting urine separately from each kidney.

abscess or renal carbuncle and the differentiation between infection alone and infection associated with renal or ureteral stone, hydronephrosis, movable kidney and pyonephrosis. The latter call for diagnostic measures in addition to the usual complete physical examination with blood and urine tests.

**Specul Fraternities of the Physical Examination in Cases of Urinary Infection**—a. An especially careful search for possible foci of infection outside the urinary tract.

b. An examination of the external genitalia. In males

the caliber of the urethral meatus and the lumen of the urethra the possibility of residual urine in the bladder and the presence or absence of infection in the prostate and seminal vesicles must be considered. In females there should be an examination for endocervicitis, cervical erosions, salpingitis, calibration of the urethra for stricture and if there is vaginal evidence of a relaxed bladder floor (cystocele), an estimation by catheter for possible residual urine.

c. Urinalysis and urine culture. In the male a voided specimen is usually sufficient for proper urinalysis while in the female a catheter specimen may be necessary. Urine cultures may be obtained in the male, after careful cleansing of the glans penis, with voiding directly into a sterile container. In the female cultures must be made from urine obtained by catheterization. In addition to complete analysis special note should be made of the relative quantities of pus cells and bacteria and smears made of the urinary sediment in addition to cultural studies. These smears should be stained by the Gram method and if there is any suspicion of urinary tuberculosis by the Ziehl-Nielsen method.

*Cystoscopy* should be reserved until it is evident that the infection is not a transitory one which will yield quickly to medicinal treatment and elimination of obvious foci of infection. In all other cases this method of visualizing the bladder and collecting the urine separately by *ureteral catheterization* of each kidney is of the greatest importance in achieving a definite diagnosis of the source, extent and character of the infection. On cystoscopy evidence of bladder infection (cystitis) is manifest, as is the presence or absence of an obstructing prostate gland, bladder stone, diverticulum or tumor, ureterocele (cystic protrusion of the ureteral orifice), stenosis or retraction of the ureteral orifices. With a catheter collecting urine separately from each kidney urine is obtained for analysis, bacteriologic examination or guinea pig inoculation. After intravenous injection of phenolsulfonphthalein or indigo carmine solution the appearance time of the dye from each kidney is noted and quantitative outputs over a given period of time may be recorded. These tests indicate in a relative measure the eliminative function of the kidneys. With an opaque catheter in each ureter roentgenograms may be made so as to show the course of the catheters and their relation to opaque areas if they are present on the films. The outlines of the interior of the renal pelvis, the calices and the ureters are made by injecting material opaque to roentgen rays into the catheters sufficient to fill them to a normal capacity. This procedure is called *ureteropyelography* and may be described as "retrograde" to distinguish it from the method of injecting substances into the blood stream which are eliminated in sufficient strength in the urine to demonstrate the outline of the renal pelvis and ureters in roentgenograms. The latter method is called "excretion urography."

A direct diagnosis of the nature, extent and severity of renal infection is made from a combined consideration of the clinical picture plus the information obtained by the aforementioned special diagnostic studies.

A differential diagnosis must take into consideration all of the lesions which may produce symptoms of fever, pain, gastrointestinal upset and abnormal urinary function. By utilization of modern methods, the diagnosis of dis-order of the urinary tract has been raised from one of clinical speculation to a most accurate and definite objective study.

Every patient who is suffering from an infectious fever, cutaneous infection or retention of urine or who must undergo a surgical operation faces the possibility of renal infection. Prophylactic treatment embraces the prevention of infection from such sources by as free elimination as possible, avoidance of dehydration, excision and drainage of localized areas of infection, the avoidance of an overdistended bladder and extreme gentleness and careful asepsis in the passage of catheters or other instruments into the bladder.

#### A. Treatment of Acute Renal Infections.

—a. *Supportive treatment* includes rest in bed, proper diet, a fluid intake of 3 to 4 quarts daily (by mouth, proctoclysis, hypodermoclysis or vein as the occasion demands) and attention to proper bowel elimination, augmented by mild catharsis or enemas if necessary. Anti-septics by mouth are largely valueless in acute pyelitis, as they may upset the stomach and are excreted in too great dilution to be of value. Large doses of alkali are sometimes helpful in preventing acidosis and in reducing the edema of the urinary passages. Urinary antiseptics given intravenously are occasionally used with effect in some cases of severe renal infection. Those most frequently used are mercurial solutions (mercuurochrome, metaphen), neo-salvarsan and hexamethylenamine.

#### b. Cystoscopic or Surgical Treatment—

If the temperature continues to be elevated, if there are repeated chills or if the toxic symptoms are evidenced by rapid pulse, nausea, vomiting and distention, there is either retention of urine in the kidney pelvis or suppuration in the parenchyma of the kidney, and drainage either by ureteral catheter or by surgical intervention (decapsulation of the kidney, nephrotomy) is indicated. Occasionally an acute suppurating kidney must be removed (nephrectomy).

**B Treatment of Chronic Renal Infection**—This includes (1) drugs to change the reaction of the urine (2) urinary antiseptics (also the ketogenic diet) (3) ureteral catheterization ureteral dilation ligation of the renal pelvis dilation of the urethra (4) the elimination of foci of infection in other parts of the body and (5) operative measures

1 A time honored method of administering drugs which alternately acidulate and alkalinize the urine has found favor with many practitioners especially pediatricians. This is based on the laboratory evidence that the gram negative bacilli (colony typhoid group) which are found in about 75 per cent of all cases of urinary infections are inhibited in growth when the hydrogen ion concentration of the urine is below 5.5 and above 7.5. This is merely a supportive or palliative measure and rarely in itself effects permanent sterilization of the urine. Drugs used for alkalization include potassium citrate sodium citrate (60 or more grains daily) or sodium bicarbonate in larger doses. For acidulation the following are of value: acid sodium phosphate 60 or more grains daily ammonium chloride 40 or more grains daily and ammonium nitrate or sodium benzoate in similar dosage. Recent studies of the effects of a ketogenic diet show that dietary measures are more efficient in obtaining the lowest possible hydrogen ion concentration (greater acidity than is obtained even by a tolerance drug dosage by mouth).

2 *Use of Urinary Antiseptics*—Countless so called urinary antiseptics are made available to the profession and the public by commercial drug manufacturers. Their number suggests that none is universally or satisfactorily effective in destroying the bacteria in the urine. These drugs fall in two general classes: (a) formalin splitting and (b) dye containing. The oldest and still most helpful drug in most urinary infections is one which is composed of some derivative of hexamethylenamine and which when excreted in a definitely acid medium splits off formaldehyde in the urine. The resultant formic acid has an inhibiting effect on bacterial growth. The objections to the drug are the necessity for a high acidity of the urine and the possibility of causing renal irritation in

some subjects. The use of drugs which contain dye substances that are selectively excreted by the kidney presupposes the liberation of antiseptic properties in sufficient concentration to be bacteriostatic. In an occasional patient one or the other of these drugs may be very effective but in the main they are inert and expensive and frequently cause gastrointestinal irritation.

The employment of a *ketogenic diet* is a method of controlling the degree of acidity of the urine and purposely for urinary antiseptics is creating a condition of mild acidosis. The diet is one of excess fat free protein and only such carbohydrate as is contained in 5 per cent amount in vegetables. As a result of the proper application of this diet acetone and diacetic acid appear in the urine the acidity is reduced from pH 5.2 to pH 4.4 and beta oxybutyric acid is found in the urine. The combination of the high acidity which is unfavorable to bacterial growth and the presence of beta oxybutyric acid which is said to be bactericidal constitutes the rationale of the method. It is noted by some observers that *Escherichia coli* and not *Ketogenes coli* are destroyed in ketosis. Others believe that it is effective in both types of infection. The diet is particularly easy to control in children and is most effective in pyelitis during infancy and childhood.

Mandelic acid has largely replaced the ketogenic diet. For adults 12 Gm of mandelic acid is given daily in the form of sodium or ammonium mandelate. A smaller dose is given to children and infants. The urinary concentration must be kept high by restricting fluids to 1000 to 1200 cc for the twenty-four hours. The pH of the urine must be kept below 5.5 by an acidish diet or the addition of acidulating drugs such as ammonium chloride or ammonium nitrate. This regimen should not be continued longer than two or three weeks. The urine must be examined frequently for the appearance or increase of red blood cells and casts. These signs of renal irritation call for cessation of treatment with mandelic acid. In instances of renal insufficiency it may be impossible to give the drug because of the severe acidosis resulting. Contraindications to mandelic therapy other than renal insufficiency are repeated attacks of nausea vomiting and hyperper-

Calcium mandelate is a much more palatable medium for mandelic therapy than derivatives of either the sodium or the ammonium salts and its ingestion is followed by less gastrointestinal disturbance.

*Sulfanilamide* (prontylin) an azo dye is in some respects a most effective urinary antiseptic although the toxic reaction induced in many cases precludes its universal application. This drug is excreted in concentration in the urine dependent on the dosage by mouth. At present oral administration appears just as or more effective than the intramuscular or intravenous routes. Sulfanilamide is frequently effective for most of the bacterial infections and is the only drug available at present which will destroy *Bacillus proteus*. Coccic infections of the urine may or may not be eradicated by sulfanilamide. *Streptococcus faecalis* does not respond. This drug is active possibly more so in alkaline urine. It is therefore advisable to keep the pH at 7.5 or higher. Large quantities of fluid (3000 to 5000 cc daily) should be ingested. Bactericidal urine develops even in instances of renal insufficiency. The dosage is as yet not standardized. When the drug is given in large doses the initial quantity is usually 60 to 80 grains daily divided into four doses. After the third day the dose is reduced to 40 grains daily and from this time on gradually it is reduced to 15 grains daily for a sufficient period to insure sterile urine. If a larger dose cannot be tolerated an initial dose of 15 to 20 grains daily may be continued for two or three weeks. Since many patients do not tolerate this drug careful almost daily observation should be the rule. Many bizarre reactions occur. Progressive cyanosis, hemoglobinuria, hematuria, fever, leukopenia, agranulocytosis, erythema, dermatitis, anemia, jaundice, muscular weakness, fatigue and retinitis are all symptoms which contraindicate continuance of sulfanilamide therapy. Prompt recovery usually ensues with discontinuance of the drug. Several deaths have been reported in conjunction with this therapy but in carefully observed patients no serious results have been reported. Frequent blood counts should be made and no type of sulfate especially magnesium sulfate should be given during the administration of sulfanilamide. The exact manner in which sul-

famamide acts as a bacteriostatic agent is not clear. Some observers believe the essential reaction is biologic while others feel that the microorganisms are destroyed by a purely chemical action. A reasonable tenet seems to be that after the killing of the microorganisms the biochemical products of this destruction are absorbed and in the process of absorption they act as a vaccine and thus increase the resistance of the body to the infection. The fact that large doses produce a severe reaction sometimes fever when first given and fail to produce such reactions after the infection has begun to subside helps to sustain this thesis.

The improvement in the efficacy of the sulfa drugs has been so rapid that it will undoubtedly be difficult for any textbook to keep abreast of the times except by frequent re-edition. Sulfapyridine superseded sulfanilamide as a urinary antiseptic only to be rather quickly replaced by sulfathiazole. The newer drug sulfadiazine may replace sulfathiazole in the treatment of urinary infections since its ingestion seems to be followed by fewer toxic reactions. The initial dose of these latter drugs is 45 grains daily for the first two to three days and then 30 grains daily, gradually reduced to 15 grains until at least two negative urine cultures have been obtained. When these drugs are taken with milk and nicotinic acid ( $\frac{1}{2}$  grain tablet) the undesirable reactions are reduced.

Experiments are proceeding along this line and a more efficient urinary antiseptic drug than is yet available may result.

*Penicillin* therapy is strikingly effective in certain types of coccic infection of the genitourinary tract. There is no pretherapeutic way of determining which of the infecting strains will be sensitive to this form of treatment. In general most forms of staphylococci and pneumococci are rapidly eliminated from the urine by the intravenous or intramuscular injection of penicillin. The hemolytic streptococci (especially Lancefield group A) are fortunately uncommon invaders of the urinary tract but when present in pure culture are usually eliminated by penicillin. Hemolytic streptococci other than those in group A and *Streptococcus viridans* may or may not be favorably influenced by penicillin. Infections due to

gonococci and meningococci are almost invariably eliminated rapidly by penicillin therapy. In general the dosage used in all genitourinary infections varies from 10-20 000 units intramuscularly every three to four hours. The duration of treatment is dependent on the severity and extent of the infectious process and on the rapidity of clinical response. In genitourinary infections an aggregate of 100-300 000 units of penicillin usually constitutes the minimum dose. In general if there is no clinical response in four or five days continuation of penicillin therapy is not indicated. A large percentage of urinary infections are of the mixed type coccal and bacillary. These are usually difficult to treat with penicillin and in general are relatively resistant. Occasionally alternate courses of sulfonamide and penicillin therapy will eradicate a mixed infection of the urinary tract in a surprisingly rapid manner. Unfortunately these instances are the exception and not the rule.

3. *Ureteral catheterization* effects the drainage of infected urine that is retained in the kidney pelvis and ureter. The relief of stasis and the improvement in outflow of urine following this procedure is often sufficient to allow the natural forces of immunization in the body to destroy the infection. If there is an obstruction from scar tissue in the ureter (ureteral stricture) repeated dilation of the ureter with bougies may be necessary to open the ureteral lumen so that the urine can drain normally. Pelvic lavage, the procedure of flushing out the renal pelvis with antiseptics introduced through a ureteral catheter is helpful in promoting the immunity of local tissue by producing round cell infiltration in the wall of the pelvis and ureter. Inorganic silver solutions (silver nitrate from 0.5 to 5 per cent) are most effective. Irrigation of the renal pelvis and calices with a solution of penicillin containing 100 units per cubic centimeter has given beneficial results in coccal types of pyelonephritis. Dilation of a urethral stricture sometimes relieves the stasis in the bladder which is the source of both renal and vesical infection.

4. Elimination of foci of infection in other parts of the body is necessary to prevent the continued or recurrent flow of bacteria to the kidney. Tonsils, teeth, sinuses, appen-

dicitis, salpingitis, intestinal infections, otomycosis, respiratory infections, etc. must be properly treated.

5. *Operative measures* include all procedures necessary to insure removal of an overwhelming infection or perpetuate normal pelvic, ureteral or bladder emptying. Nephrectomy in severe infection, correction of hydronephrosis or abnormal renal mobility with kinking of the ureter, removal of renal or ureteral stone, excision of hypertrophy or sclerosis of the prostate and removal of diverticula of the bladder are all included in the possible surgical indications. Pyelitis occurring during pregnancy, pyelitis in infancy and defloration pyelitis are all subject to the same diagnostic and therapeutic principles enumerated. The last mentioned condition occasionally occurs in women following the first sexual intercourse and is presumed to be due to the absorption of infection attendant on rupture of the vaginal hymen.

## INFECTION OF THE BLADDER (CYSTITIS)

Infections of the bladder may be acute or chronic, superficial, interstitial or perieystic (involving the tissue surrounding the bladder).

*Etiology*—The common routes of infection are from the kidneys by way of the ureter and direct extension from the posterior urethra. Less common routes are by way of the blood stream (hematogenous) and by a fistula between the bladder and some adjacent structure. The normal bladder is very resistant to bacterial invasion and inflammation of the bladder usually implies prolonged or severe descending infection, retention of urine, congestion or predisposing trauma.

The infecting organisms correspond with those of the kidney and renal pelvis above but with the addition of the gonococcus which in fact invades the trigonal structures and rarely produces a diffuse cystitis. Syphilis of the bladder, amebic cystitis and bilharziosis are very rare afflictions except in isolated localities and are hematogenous in origin.

The predisposing factors which favor localization of bacteria in the bladder are (a) all the various causes of residual urine, (b) pregnancy, cold foci of infection and (c)



trauma from prolonged overdilatation (as after surgical operations) and the introduction of unclean instruments or strong corrosive solutions

**Causes of Residual Urine in the Bladder**—**Common to Male and Female**—Bladder Obstruction due to tumors diverticula stones foreign bodies Urethra Obstructions due to stricture and tumor *Atony of the detrusor muscles* of central origin as in tabes multiple sclerosis myelitis or syringomyelia or from pernicious anemia from trauma to the cord or spine or from a tumor of the spinal cord

**Male Only**—Obstructing prostate benign and malignant median bar sclerosis of the vesical orifice urethral diverticulum or foreign body and phimosis

**Female Only**—Cystocele pressure from a uterine tumor prolapse of urethra and uterus and following parturition

**Pathology** *Acute cystitis* is characterized by hyperemia of the mucous membrane dilated capillaries small areas of submucous hemorrhage and patches of localized edema The mucosa may be partially covered by a fibrinous exudate or small superficial ulcers may be extensive with sloughing or even gangrene In *chronic cystitis* the lesions are variable The mucosa may be regularly thickened and hyperemic with marked localized areas of edema There may be white patches of cornification of the epithelium (leukoplakia) or minute cystlike formations along the course of the blood vessels (cystitis cystica) If the urine is alkaline there may be ulcerations covered with crustations of calcium salts (crystalline cystitis)

*Interstitial cystitis* or Hunner's ulcer is a chronic inflammation which occurs in the submucosa of the bladder involving the submucosa and muscularis but to a less extent the mucosa The involved areas are sclerotic and elastic and when the bladder is distended the mucosa cracks and bleeds The lesion appears as a localized hyperemic area with striated dilated capillaries entering it and the center occupied by one or more minute ulcerations

**Symptoms**—Cystitis generally speaking is a symptom and not a disease Its presence is evidenced by painful frequent urination pyuria and occasionally localized pain and hematuria These symptoms vary according to the severity of the infectious reaction in the bladder and not according to the duration of the disease

Acute cystitis is of sudden onset with frequent and painful urination The disturbance may vary from mild burning on voiding associated with exaggerated day and night fre-

quency to a condition of violent pain and spasm with marked urgency and frequency There may be severe terminal bladder spasm and hematuria Pus is constantly present in the urine Except in interstitial cystitis there is no suprapubic pain and all the discomfort is referred to the neck of the bladder urethra perineum or glans penis

Chronic cystitis is usually a secondary lesion and the symptoms are those of a lessened capacity of the bladder and increased irritability of the sphincters Nocturia urgency and dysuria therefore may be mild or severe The infections which occur when there is acid urine with the exception of tuberculosis are relatively mild symptomatically while alkaline cystitis is usually most painful and irritating

Incurred ulceration of the bladder is due to a urea splitting organism which produces intense cystitis with ulcerations of the mucosa of the bladder These areas are covered with calcareous incrustations which cause marked frequency and spasmodic pain The urine is turbid and ammoniacal and contains lime salt grit

*Interstitial cystitis* Hunner's ulcer occurs in the vertex and lateral walls of the bladder The elastic wall is replaced by scar tissue in localized areas and the capacity of the bladder is greatly reduced Suprapubic pain marked urgency at times amounting to incontinence and hematuria on overdistention are the cardinal subjective symptoms The urine is usually clear and sterile and contains only microscopic blood with rare pus cells

**Diagnosis**—Cystitis is suspected by the history of frequency and dysuria and confirmed by the finding of pus in the urine No diagnosis is complete unless the character and source of the infection are determined unless the complicating or additional lesions are located and unless evidence is obtained as to whether one or both kidneys are infected Frequent and painful urination suddenly complicating pre-existing urethritis indicates that infection has extended to the posterior urethra and trigone In acute pyelitis bladder symptoms indicate involvement of the mucosa of the bladder If fever exists with bladder symptoms either a complicating renal or prostatic infection is assumed

Pyuria and positive bacterial growth from the urine confirm the diagnosis. The presence or absence of residual urine in either sex should always be established. The reaction of urine and stained smears of the sediment help in the identification of the bacteria which should later be confirmed by culture. Pronounced bladder symptoms with little pus and no bacteria suggest either interstitial cystitis or tuberculousis.

Cystoscopy must be used when it is necessary to examine the kidneys and ureters and to differentiate the different types of cystitis, the presence of diverticula, stones, tumor, prostatic obstruction and other complicating lesions.

**Treatment**—Relief of cystitis depends on adequate treatment of the causative disease. This may require a complete survey of the urinary tract and allied organs. Palliative treatment in acute cystitis consists of rest in bed, forced fluids, alkalinization of the urine and sedatives. Some mixture of codeine and hyoscyamus serves best. Urinary antiseptics are not usually helpful in acute cases because of the dilution of the urine and alkalinization. Local treatment is rarely needed unless there is residual urine. In the latter case, interval catheterization or an indwelling catheter may be used with soothing antiseptic irrigations or instillations.

The treatment and special methods of diagnosis for chronic cystitis are the same as for renal infections and have been described fully. Local medication may be used to allay symptoms and hasten cure. Irrigations and instillations of soothing or stimulating solutions are not in vogue as previously but are occasionally effective. Chronic ulcers and localized inflammations of the bladder wall may be treated by cystoscopic fulguration or topical application of solutions of silver nitrate.

### HYDRONEPHROSIS

Hydronephrosis is the term applied to a pathologic condition resulting from mechanical interference with the outflow of urine from the kidney. It is characterized by distention of the renal pelvis and calices and retention of urine and may eventually lead to atrophy of the renal parenchyma, destruction of function and conversion of the kidney into a fibrous sac. One or both kid-

neys may be involved. When unilateral it is usually the result of an obstructive lesion above the point of entrance of the ureter into the bladder; when bilateral it may be due to obstruction of both ureters, but more often it is the result of mechanical obstruction at the outlet of the bladder. The urine retained in the hydronephrotic sac may be sterile or infected.

**Etiology**—1 *Obstructive lesions* (congenital or acquired, intermittent or continuous, complete or incomplete).

*Kidney stones*, aberrant vessels or bands exerting pressure on the upper ureter or pelvic tumors or ptosis of the kidney with kinking at or near the ureteropelvic junction.

*Ureter stones*, strictures, kinks and tumors, pressure from without by new growths, inflammation or a pregnant uterus, ligatures accidentally applied in pelvic surgery.

*Bladder stones*, tumors and obstructive prostatic lesions at the outlet.

*Urethra*, congenital valves, acquired strictures and stenosis of the external meatus.

2 *Paralytic lesions* (faulty innervation), injury to the spine (fracture) or in tumor of the spinal cord, etc., lesions of the cord, tabes dorsalis, myelitis, syringomyelia or spinal bifida, or late changes associated with pernicious anemia.

3 *Overgrowth of tissue* is the cause sometimes assigned to ureteral dilatation (megalo-ureter) for which no obstructive or paralytic cause can be demonstrated (supposed analogy to Hirschsprung's disease or megacolon).

**Pathology**—The renal pelvis is dilated in varying degree (the normal adult pelvis has a capacity of about 10 cc.) and the parenchyma is normal or progressively compressed by the back pressure. The dilatation may involve only half of the kidney. If there are two ureters or a single calyx may be obstructed. In early cases sections show flattened papilla and a thinner medullary zone and the tubules are dilated and distorted. In advanced cases only a thin smooth wall remains with fibrous septums remaining. The thin remaining cortex presents hypertrophy of the renal cells and glomeruli with marked sclerosis of the vessels. The size may vary from that of a normal kidney to a cyst like shell filling half the abdominal cavity.

**Symptoms**—The symptoms are extremely variable. There may be none unless the hydronephrosis is complicated by infection or the formation of a stone. Pain, pyuria and hematuria are usual symptoms. Occa-

sionally a tumor is felt in the loin or upper abdomen. Pain may be felt in the lumbar region and back or it may be referred to the abdomen with accompanying vague symptoms of nausea vomiting and disturbed digestion. It is usually of a dull aching character but when sudden added retention occurs it may become sharp severe and colicky.

Pus in the urine may be the only finding or an associated cystitis with frequency dysuria and hematuria may call for a study which may show that an infected hydronephrosis is the primary factor.

It should be emphasized that complete absence of both urinary symptoms and signs does not rule out the possibility of hydronephrosis and this condition should be borne in mind in the differentiation of all vague abdominal complaints of chronic or recurrent nature.

**Diagnosis**—Unfortunately even a large hydronephrosis is difficult to palpate accurately. When palpable the mass is that of a smooth elastic tumor usually felt in the loin by bimanual pressure and is not hard or nodular as in tumor or cyst of the kidney. The diagnosis must be confirmed by ureteral catheterization retrograde pyelography or excretion urography.

When the ureteral catheter is passed into the hydronephrotic sac there is a rapid flow of thin limpid urine and aspiration with a syringe shows the amount of retention. The excretion of dye is diminished in an amount corresponding to the extent of renal destruction. The roentgenograms demonstrate the outline of the dilated pelvis and calices and give an indication of the etiological factors.

**Treatment**—The method of treatment depends on the causative factor and the extent of destruction of renal tissue. The removal of obstructive lesions of the bladder and urethra may relieve renal dilatation from these sources (urethral meatotomy progressive dilation of a urethral stricture cystoscopic cautery destruction of valves electric resection of prostatic tissue or prostatectomy). It is advisable to discover obstructive lesions in the ureter or kidney before advanced renal destruction has occurred. In well advanced hydronephrosis if the other kidney is inadequate or if the dilatation is bilateral treatment must consist of such

measures as cystoscopic dilation of a stricture removal of a stone nephropexy or a plastic operation on the kidney or ureter. If one kidney is irreparably damaged and the other maintains its normal function nephrectomy should be performed. Occasionally when one half of a kidney is hydronephrotic as in obstruction of a major calyx heminephrectomy may be carried out. The latter procedure may also be indicated when there is hydronephrosis in half of a double kidney.

### PERINEPHRITIC ABSCESS

Perinephritic abscess implies an infection outside the capsule of the kidney (paranephritis) with resultant necrosis of the perirenal fat and frank suppuration in the renal fossa.

**Etiology**—The perirenal space is infected through the blood supply which is independent of that of the kidney proper or by extension of infection from the kidney itself or by contiguity from adjacent structures. The primary organism is usually the staphylococcus although the colon bacillus may be a secondary invader. The primary focus is most commonly a cutaneous infection such as a furuncle carbuncle cellulitis or paronychia. Respiratory foci and infections in the mouth also contribute but in lesser degree to perirenal infection. Chronic cortical abscess carbuncle of the kidney pyonephrosis and contiguous intra-abdominal suppurations constitute the locally direct causes.

**Pathology**—The perirenal fat becomes edematous thickened and infiltrated. Minute areas of suppuration coalesce to form larger areas of liquefaction and eventually the entire renal fossa may be filled with pus.

**Symptoms**—The constitutional manifestations of perinephritic abscess are much like those of infections in the renal cortex. The onset is insidious and suggests "grippe" or respiratory infection without localizing signs. Fever is intermittent and chills and sweats may be frequent but local symptoms are commonly not pronounced until the suppuration is marked. Leukocytosis is high and the urinary findings are normal unless the infection breaks through to connect with the urinary tubules. With the patient lying on his face or sitting a definite fullness may be noticed in the loin of the affected side. When the condition is well advanced the

mass in the loin is fixed and diffuse in outline. When the abscess is confined to the kidney the mass may be movable and more easily outlined. Pain is usually limited to the costovertebral region. Occasionally the abscess develops very rapidly producing septic symptoms which necessitate immediate incision and drainage. In such a case there is bulging in the loin and retroperitoneal extension downward producing distention and paresis of the intestines. There is often edema of the overlying tissues.

**Diagnosis**—In the early stages the diagnosis is not easy and must be arrived at after sufficient time has elapsed so that other septic conditions can be carefully excluded. One may often suspect perinephritic abscess from the history and vague physical findings but may be unable to decide definitely until some localizing signs appear. The history of prior infections and the intermittent and vague course of fever, malaise and backache associated with marked leucocytosis when supplemented by localized tenderness in the loin suggest perirenal suppuration. In the early stages the urine may be normal and signs of infection may gradually develop or the analysis may be normal throughout. Ureteral catheterization and renal function tests help little or not at all. The roentgenographic findings are most helpful. *Scoliosis* is the most important sign, the curvature being away from the involved side and probably resulting from contraction of the spinal muscles near the suppuration. *Obliteration of the marginal outline of the psoas muscle* is also important and may appear early. Of course any enlargement of the kidney may produce this such as that due to a nephroblastoma, cyst and hydronephrosis, but as a rule the clinical picture is different. When great liquefaction occurs the entire shadow of the kidney and the outline of the psoas muscle are obscured by a homogeneous density on the affected side. Upward displacement of the diaphragm, distortion of the ureteral outline and anterior displacement of the colon also may be evident.

**Treatment**—Incision through an approach in the costovertebral region must insure free retroperitoneal drainage and complete evacuation of the abscessed areas. In rare instances it is necessary to expose the kidney so as to drain the localized

pockets or to inspect the cortex of an abscess or carbuncle. In the main a rapid cure without complications is the result.

### TUBERCULOSIS OF KIDNEY, URETER AND BLADDER

Tuberculosis of the urinary tract begins in the kidney but is always a secondary lesion caused by the deposition of tubercle bacilli from the blood stream. The respiratory system is most frequently the original focus, nodes in the hilum giving off bacilli which enter the blood stream through the lymphatic duct. Mediastinal, cervical and mesenteric nodes are therefore the common original foci. Modern evidence controverts the old theory that a healthy kidney may filter tubercle bacilli into the urine from the blood stream. A lesion is always present in the kidney when bacteria are revealed in the urine excreted by that kidney. It is possible that renal tuberculosis is frequently a bilateral condition in its inception but that one kidney resists the infection while the other succumbs, resulting in the more common clinical condition of unilateral disease. Tuberculosis is one of the most destructive of renal lesions. The kidney is involved in about 10 per cent of all patients dying of tuberculosis and in 1 per cent of all autopsies.

**Etiology**—*Surgical tuberculosis* of the kidney is predominantly a unilateral condition. Clinically it is bilateral in about 20 per cent of the cases while autopsy shows bilateral infection in 50 per cent. It is probable that if careful serial sections were made in this latter group a high percentage of small healed lesions would be found. The disease is most common in early adult life between the ages of eighteen and forty but may occur at any age. Usually no predisposing cause can be determined but it is probable that trauma and stasis play a part in other infections of the urinary tract.

As already stated tuberculosis of the kidney is a secondary process but the primary lesion is not evident in some 75 per cent of the patients seen clinically. Genital lesions in the male are associated in from 50 to 100 per cent of cases.

**Pathology**—The lesion begins as a tubercle in the renal cortex or pyramid. The initial pathology is that of a collection of round and giant cells surrounded by an area of fibrosis. As the condition progresses, casea-

tion and cavity format on an invasion of the pelvis ureter and bladder are noted. The disease spreads throughout the kidney via the intertubular lymphatics and multiple nodules and caseous cavities may occupy renal tissue or may dot the surface of the kidney or ureter. If the cavities coalesce the kidney may become a mere shell. Ulceration and thickening of the ureter may obstruct the kidney and result in pyonephrosis. Occasionally the descent of the process is halted by complete tuberculous occlusion of the ureter a condition termed autonephrectomy. If the lesions are less destructive a small contracted kidney may result and in this event there is fibrotic replacement of the cortex with fatty infiltration. Calcification may occur in the caseated areas. The ureter is secondarily infected from the kidney and ulceration thickening of the walls tortuosity and stricture format on occur. Involvement of the bladder occurs very early at first a superficial invasion of the mucous membrane later extending to the submucous layers. The process often begins about the corresponding ureteral orifice as a red lined edematous area later small tubercles may cover this region. These caseate and ulcerate and as fibrosis occurs the ureter retracts the orifice remaining patulous (golf hole appearance). Large submucous areas of the wall of the bladder become fibrotic and contraction of the bladder with marked diminution of capacity results.

**Symptoms**—The earliest and most persistent symptom of renal tuberculosis is frequency of urination. An associated polyuria causes this frequency to be decidedly more annoying at night. As ulcerations appear and the vesical wall is invaded the frequency is accompanied by pain which at first is terminal but later becomes continuous. Urination becomes more and more frequent as the capacity of the bladder diminishes. Occasionally the bladder becomes so contracted that incontinence ensues. Hematuria either microscopic or gross, is evident from the start and occasionally a profuse hemorrhage from the kidney is an initial symptom. Renal pain is rarely found as an early symptom and may in fact never develop. There is often an aching sensation felt deeply in the loin and aggravated by exertion or jolting. Renal colic can occur from the passage of blood or inspissated pus crystals. There may be tenderness over the region of the kidney on deep palpation first percussion of the back may elicit local pain and occasionally an enlarged kidney is outlined. The general symptoms may be fever night sweats loss of weight and digestive disturbances.

**Diagnosis**—Tuberculosis should be suspected in any young or middle aged person who complains of nocturia and progressive

frequency of urination. Unless hematuria occurs the urine is clear and acid and usually contains no ordinary pyogenic bacteria. Late in the disease secondary infection may occur but is not common. The diagnosis is determined by the finding of tubercle bacilli in the urine and by localization of their source by cystoscopic examination and ureteral catheterization. Urine must be obtained so that the smegma bacillus which is also acid fast does not contaminate the urine. Careful external cleansing in the male and catheterization in the female will obviate this difficulty. The lesions in the bladder as seen at cystoscopy are usually suggestive and examination of the urine from either kidney will show the presence of infection and the functional excretion of dye. If the bacilli are not easily identified in smears from the urine it may be necessary to culture the urine on special media or to inject it into a guinea pig as a culture medium. Ureteropyelography may show dilatation tortuosity and stricture of the ureter and moth like filling defects in the outline of the renal calices. The isolation of the organisms is often tedious and difficult even after one feels sure that tuberculosis exists. The functional condition of the unaffected kidney must be carefully studied. In the differentiation such local causes of vesical irritation as prostatic infection stone stricture and gonorrhea are easily recognizable and these usually respond to local treatment whereas tuberculosis does not. The greatest difficulty in diagnosis is encountered in cases of chronic low grade pyelocystitis of pyogenic origin and in interstitial cystitis a persistent disease associated with a contracted bladder and sterile urine.

**Treatment**—A patient with bilateral renal tuberculosis must be treated as in severe advanced pulmonary tuberculosis. In these cases the prognosis as to cure is usually hopeless although the patients may live miserably for a number of years. While early spontaneous healing may occur such a result is practically never seen if the symptoms are severe enough to bring the patient to a doctor. Removal of the affected kidney (nephrectomy) in unilateral cases is followed by a clinical cure in from 60 to 75 per cent of cases depending on the extent of the disease and the environment for con-

rescence. The same medical and hygienic care that is accorded all tuberculous patients should be followed in cases of tuberculosis of the urinary tract. In some instances it is well to remove the ureter as well as the kidney on the affected side. Tuberculosis of the bladder may persist after nephrectomy and presents a serious problem. The judicious use of tuberculin preferably given intradermally seems helpful as a postoperative procedure.

### TUBERCULOSIS OF THE EPIDIDYMIS

Tuberculosis of the epididymis is a frequent lesion but involvement of the testis is rare. An unsettled controversy continues as to whether the original genital focus is in the epididymis or in the prostate and seminal vesicle. Since combined lesions of these structures usually occur it is usually impossible to be sure in which organ the tuberculous process commenced. Genital tuberculosis as renal is always secondary to tuberculous elsewhere in the body. Whether the tubercle bacilli reach the epididymis through the blood stream or whether the infection occurs secondary to a preexisting focus in the prostate and seminal vesicles is of academic importance. Both routes are probable. The local resistance process usually begins in the globus minor as a more or less painless hard nodule which enlarges gradually and is accompanied by nodular headlike thickening of the vas deferens. In the indolent slow lesions there is gradual involvement of the entire epididymis followed by nodular extension to the scrotal skin and multiple purulent sinus formation. Rarely acute tuberculous epididymitis occurs which is difficult to differentiate from gonorrhea or nonspecific infection. The entire epididymis becomes acutely swollen and tender; scrotal redness and inflammatory leukocytic infiltration cause a diffuse enlargement. These acute reactions usually subside with rest and palliative treatment. The process then resembles the miliary form.

The differential diagnosis includes all conditions which cause scrotal enlargement. Preoperative treatment needs attention to careful hygienic rest, chemotherapy, graduated injections of old tuberculin intradermally and proper dietary measures. Surgical excision of the epididymis and a portion of the vas deferens with preservation of the testis should be done only after the acute reaction has subsided and the general resistance of the patient has been increased. Genital tuberculosis accompanies renal and vesical lesions in from 90 to 95 per cent of cases.

### ANTERIOR URETHRITIS IN THE MALE

The term *urethritis* indicates infection of the urethral mucous membrane and its associated crypts and glands. The term *anterior urethritis* designates the condition in which the involved area extends only to the triangular ligament (external sphincter) leav-

ing the membranous and prostatic portions unaffected.

The anterior urethra most commonly becomes infected from outside the body either through the external meatus. The gonococcus, trichomonas and colon bacillus are the usual invaders and are most frequently introduced during the sexual act.

Secondary infection of the urethra occurs by contiguity from adjacent upper genital or urinary structures or by contamination of infected urine. Prolitis, exstis and proctitis are the common contributing sources. Colon bacillus, streptococcus, staphylococcus and more rarely the pneumococcus are the excreting organisms. Tuberculosis of the male urethra is rare but occurs occasionally secondary to extensive genital and renal infection.

Urethritis is said to be *specific* if caused by the gonococcus and *non specific* if due to other organisms. Intraurethral chancre (primary lesion of syphilis) is not to be considered as a urethritis in the strict sense.

In general the causative factor of urethritis is (1) bacterial (2) chemical or (3) traumatic. Chemical and traumatic causes constitute merely additional primary reactions in the urethral mucosa which lower the vitality of the tissues and allow bacterial urethritis to supervene. Thus the injection of caustics and the effects of external or internal injury pave the way for bacterial growth within the urethra and should not be described as separate types of urethritis.

The urological aspect of the diagnosis and treatment of urethritis is to be found in texts on genitourinary diseases and only the surgical complications which may arise in the course of the various types of infection will be considered here.

**Complications of Anterior Urethritis.**—Balinitis, phimosis, lymphangitis, periurethritis, periurethral abscess, inguinal adenitis and urethral fistula are the most common complications and arise secondarily to gonorrheal infection in greater frequency than from non specific infection.

*Balanitis* is a diffuse inflammatory reaction in the preputial skin with swelling, edema and redness due to lymphatic obstruction. The diagnosis is self evident and treatment consists in frequent cleansing of the parts, prolonged application of hot

moist compresses to promote absorption and proper attention to the urethral infection. All patients with balanitis should be carefully examined in order to discover the possibility of an underlying chancre as the concealed cause rather than the obvious urethritis. If the swelling does not subside promptly and if there is any evidence of necrosis or sloughing of the skin the condition is more probably due to an anaerobic infection caused by the spirillum this condition being called *erosive and gangrenous balanitis*. Continuous diligent application of peroxide potassium permanganate or other oxidizing antiseptics must be employed to prevent extensive destruction. Surgical incision is rarely if ever indicated in balanitis.

*Phimosis* designates localized swelling, tightness and irretractability of the terminal preputial skin. This results in retention of urethral discharge and secretion and may excite balanitis and lymphangitis. Hot applications, cleansing irrigations and repeated attempts to loosen and retract the foreskin should be tried but if they are not quickly successful the foreskin should be incised over the dorsum of the penis. This *dorsal slit* is made with infiltration anesthesia and a few sutures of silk or catgut are used to approximate the cutaneous surfaces. Circumcision if indicated should be done at a later date when the acute inflammatory reaction has subsided.

*Lymphangitis* is characterized by hard cord like infiltrations in the dorsal and lateral skin of the penis due to inflamed and obstructed lymphatics which may appear as red lines sometimes reaching 1 cm. in diameter. Hot fomentations, medical diathermic heat and rest of the parts usually result in softening and improved drainage in from three to five days. These areas should never be incised surgically unless secondary infection occurs.

*Inguinal adenitis* results from regional infection and may be found with or without secondary balanitis, phimosis or lymphangitis. The nodes in one or both groins become enlarged and tender. Rest and induced heat combined with proper local treatment usually result in prompt subsidence of the adenitis. In some cases however the glands break down, become fluctuant and require surgical incision and maintenance of proper

drainage until healing has occurred. Adenectomy is not advisable unless repeated suppurations of a low grade character persist for some times.

*Periurethritis* evidences itself by the appearance of localized nodular infiltrations along the ventral aspect of the penis. This condition is due to localized retained infection in a periurethral gland. Hot applications of induced heat by medical diathermy result in absorption, urethral drainage or the formation of a localized *periurethral abscess*. This condition appears as a rounded fluctuant ball or mass on the floor of the urethra. Incision and drainage without entering the urethra itself is advisable. This localized area then either heals and becomes obliterated by fibrous tissue or the mucosal elements grow down from the urethra to the skin and form a *urethral fistula*. This latter condition may prove most troublesome in that there is leakage of urine and irritation and also that the fistulous tract offers an ideal area for persistent harboring of gonococci. The fistulous tract may be closed by repeated cauterization with solution of silver nitrate or other caustics. Coagulation of the tract by the actual cautery or by a wire electrode of high frequency current is often successful. If these measures fail excision of the tract and careful closure of the urethral floor and outer skin in separate layers is indicated. In rare instances when the urethral defect is extensive it is advisable to divert the urine by perineal drainage or suprapubic cystostomy for two or three weeks in order to permit the operative site to heal permanently.

VINCENT J. O'CONNOR

## INJURIES TO THE KIDNEY

*Contusions, rupture and bullet wounds* of the kidney are of great importance. Although the kidney is fairly well protected from trauma by its location and mobility, injuries to it are more common than formerly mainly because of the increasing frequency of automobile accidents. Athletic sports also contribute their share of renal injuries.

The mechanics involved in contusion and rupture of the human kidney are best demonstrated by experimental studies. In the writer's experiments it was found impossible

to rupture the fibrous capsule of a dog's kidney by striking its surface with a blunt instrument although various degrees of injury could be inflicted on the cortex depending on the force used. The injuries produced varied from light subcapsular hemorrhage to complete pulpefaction of the traumatized portion of the cortex.

**Pathology**—When the fibrous capsule is opened following injury brisk bleeding always occurs and in the case of severe injury serious hemorrhage is noted. In every case in which operation is performed early this is readily controlled by applying thin particles of fat to the region of the bleeding points and repairing the wound by the use of plain ribbon gut fixed in position by means of straps made in the fibrous capsule.

After actual pulpefaction of a portion of the renal cortex the tissue does not seem to break down and produce an abscess unless the fibrous capsule remains intact. In the latter event the continued hemorrhage and the influence of extravasated urine from the ruptured and macerated cortex result in the ultimate rupture of the fibrous capsule owing to its digestion by the ferments released under it and abscess formation. This usually occurs some time after the injury which in itself may not have been considered severe.

**Symptoms**—Pain at the site of injury is the most prominent symptom of trauma of the kidney. This is usually accompanied by microscopic blood in the urine and if the bleeding is severe there will be the cardinal signs of gross hemorrhage: rapid pulse, air hunger, pale worried facies and a cold clammy skin. Swelling may be noted on the affected side and tenderness is always present. Absence of blood in the urine does not rule out injury to the kidney for this may be due to severance of the ureter or its complete blockage by a blood clot.

**Prognosis**—The prognosis is favorable if operation is performed early in severe lesions. If hematuria persists for more than twenty-four hours the kidney should be explored and drainage instituted.

**Symptomatic Treatment**—The pain accompanying even slight traumatism of the kidney is usually such that a strong sedative such as 1 grain of codeine or  $\frac{1}{4}$  grain of morphine is indicated. The patient should

be immediately hospitalized and the general condition carefully observed for increasing evidence of shock and hemorrhage.

**Indications for Operative Treatment**—Experience with experimental rupture of the kidney leads to the belief that many cases of renal injury are fatal because the surgeon does not operate soon enough. If shock is great the patient should be prepared by the giving of stimulation in the form of hot coffee, enemata, adrenalin, cardiac stimulants and blood transfusion and relieved of pain by sedatives. Exploration under spinal anesthesia should be carried out at the earliest safe moment. If the injury has not been grave at the outset but hematuria con-

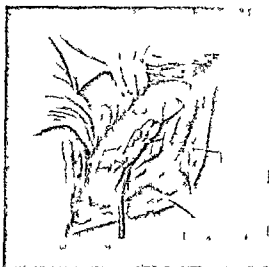


Fig. 6.0—Completed repair of a rupture of the kidney showing the drain in the pelvis of kidney and fat inserted into the ruptured bleeding portion of the cortex. Pressure sufficient to produce hemostasis is exerted by the ribbon gut.

tinues for longer than twenty-four hours the kidney should be explored. Even if there is no hematuria but the patient becomes lethargic and tenderness or swelling or both persist in the loin an exploratory operation is advisable. When in doubt, always operate.

**Principles of Operative Treatment**—The kidney is exposed in the usual manner and isolated from surrounding structures. (In cases of serious renal damage the fibrous capsule will be elevated by the underlying hematoma and the damage to the underlying renal cortex can be both seen and felt.) The capsule is opened, blood clots are sponged away and isolated wedges of



cortex are removed. Bleeding points are controlled by applying pieces of fat under pressure while plain ribbon gut is fixed in position about the kidney by means of straps made in the fibrous capsule. The ribbon gut is then tied with sufficient pressure to control the bleeding. A rubber drainage tube is passed into the renal pelvis before the ends of the ribbon gut are tied. Penrose drains are placed around the kidney to take care of the fluids that collect there, and the wound is closed in layers in the usual manner.

OSWALD S. LOWSLEY

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## INJURIES OF URETER AND BLADDER; FOREIGN BODIES AND ULCERS OF THE BLADDER

### WOUNDS OF THE URETER

Wounds of the ureter, with the exception of those incidental to surgical procedures, are extremely rare in civil practice. Even in military practice they are relatively rare in comparison to wounds of other intra abdominal organs. This is readily explained since they are well protected by their deep location and moderate mobility.

A few cases have been reported in which the ureter has been perforated by instruments introduced through the cystoscope, and there are one or two cases on record in which an impacted calculus has sloughed through the ureter wall with resulting extravasation and abscess formation. It has been fairly clearly demonstrated that it is impossible to apply enough pressure through the cystoscope to perforate a normal healthy ureter with an ordinary catheter. This however does not apply in the case of the diseased ureter. Metal instruments such as dilators forceps stone extractors etc. may and occasionally do perforate the normal ureter.

This is obviously a cogent argument against their indiscriminate use. The great majority of ureteral wounds occur in the course of surgical procedures, particularly operations deep in the pelvis, totally abdominal panhysterectomy or vaginal hysterectomy. Many gynecologists when about to undertake what promises to be a difficult hysterectomy adopt the very wise procedure of passing catheters into each ureter before operation. These serve as a valuable guide to the location of the ureter in deep pelvic operations and naturally lessen the likelihood of injury. These accidents occur rather commonly doubtless much more frequently than would appear from the literature since many cases are never reported. In fact it is quite possible to include one ureter in a ligature with no obvious untoward effect other than a moderate amount of pain or discomfort referred to the corresponding loin and this symptom would be masked by the usual postoperative discomfort incidental to any major surgical procedure. In such an event if the kidney is not infected there would be a temporary hydronephrosis followed by atrophy of the kidney. The remaining kidney could take over the entire renal function and the patient might go on to an apparent smooth recovery with a dead kidney on one side and live out her normal life expectancy totally ignorant of the fact that an accident had occurred.

Accidental operative trauma to the ureter might consist of complete ligation of one or both ureters, needle puncture with partial inclusion of the ureter caliber in the ligature cuts or tears of varying degrees in the ureter walls and finally the ureter might be entirely cut across. There is still another type of case which should perhaps be included in this group and that is the occasional case of periureteric fibrosis with resulting occlusion of the pelvic ureter following the use of radium in the treatment of carcinoma of the cervix uteri.

**Symptoms.**—Operative wounds of the ureter, except when the ureter is entirely cut across, are often not recognized at the time of accident. Complete section is usually but not always recognized at once. Complete ligation of both ureters would of course be followed by complete anuria together with pain and a sense of fullness in both loins. In cases in which the lumen of one or the other or both ureters has been opened and the flow of urine not blocked by a ligature there would be the usual symptoms of a deep pelvic infection varying in degree in inverse proportion to the amount of drainage instituted at the time of operation. In cases with no drainage the infective symptoms are fulminating and severe, chill, fever, sweating, prostration, nausea, vomit.

ing and other evidences of acute peritonitis appear, in fact, all the symptoms of an extensive intraperitoneal and extraperitoneal extravasation of urine. Since most of these accidents occur in the course of a panhysterectomy, where adequate drainage, usually vaginal, is always provided the symptoms of infection are very mild and transitory in character and may pass unnoticed. In these cases there will be from the beginning a constant seepage of urine, mostly from the vagina occasionally also through the abdominal wound. This condition is often not recognized until a period of days or even weeks has elapsed following the operation. The constant vaginal discharge may at first be attributed to serous discharge and later to a mild degree of incontinence.

**Diagnosis**—The diagnosis should be readily made if the possibility of surgical accident is borne in mind. In cases of urinary leakage from the vagina, it is of course necessary to differentiate between wounds of the ureter and wounds of the bladder.

This is readily accomplished by the following simple procedure. The patient is placed in the lithotomy position, a vaginal speculum inserted and the vagina sponged dry, a soft rubber catheter is then passed into the bladder which is then distended with some colored fluid such as a solution of methylene blue. If the blue fluid is noted escaping into the vagina it of course proves that there is a rent in the bladder wall. Conversely if no blue appears in the vagina and urine does appear it is fair to assume that the lesion is in one or the other ureter. In all cases it will be necessary to make a careful cystoscopic examination, perhaps also a roentgenographic study for the purpose of determining which ureter is involved. On the normal side a catheter will pass easily to the renal pelvis whereas on the involved side it will be blocked a short distance from the bladder. If there is any doubt a large catheter may be passed a short distance into the suspected side and skidman inserted. A roentgenogram will show the opaque fluid irregularly diffused in the surrounding area.

**Treatment**—If a wound in the ureter is recognized at the time of operation and the organ is not entirely cut across it may be closed in part with a very fine plain gut suture care being taken not to constrict the lumen and to provide adequate drainage. This latter is of course of vital importance. In fact drainage alone without the suture may be all that is required. Ureter wounds heal very kindly if given a chance.

When the ureter is cut entirely across and the accident is recognized at once, several methods of repair are possible.

The procedure of choice should be an effort to reunite the cut ends and reestablish the normal urinary stream. It is absolutely essential that the anastomosis be made without tension. If the ureter has been divided very close to the bladder wall it may be better practice to tie off the distal end and reimplant the proximal end at a higher point in the bladder. If the cut has been made higher up and it is impossible to approximate the two ends without undue tension one may revert to another expedient the feasibility of which has been recently demonstrated on experimental animals. A large catheter is passed through the bladder and distal portion of ureter then guided into perineal position to the renal pelvis the cut ends are anastomosed in this position with a few sutures loosely placed. The catheter is left in situ for several days. In the experimental animals a new tubular structure lined with epithelium has regenerated. Many operators have tied both ends and simply dropped them in the woman. If the corresponding kidney is not infected and the remaining kidney is sound it is reasonable to expect a smooth recovery. Adequate drainage is of vital importance in all cases and one must be prepared to perform nephrectomy later if occasion arises.

In cases in which the accident is not recognized until after operation the condition generally becomes apparent immediately. Occlusion of one ureter usually requires no treatment other than watchful waiting. Complete occlusion of both ureters naturally requires prompt action.

One may reopen the abdomen and carry out a degeneration. This however is often very difficult and is attended by profound shock. It is much safer and better to perform bilateral nephrastomy or pyelostomy under local anesthesia. Often the caliber of the ureters will be restored spontaneously after a period of several weeks following which the pyelostomy fistula will heal. An open wound of the ureter which drains into the vagina should not be attacked surgically until a period of several weeks has elapsed following the original operation. If the ureter is completely cut across the proximal ends should be exposed through an extra peritoneal incision and reimplanted in the bladder. Lateral wounds occasionally heal spontaneously. Recovery may be hastened if a catheter can be passed beyond the lesions and left in situ for several days. This procedure may be repeated from time to time. If any or all of these methods fail the urinary leakage can always be promptly cured by nephrectomy if the functional integrity of the remaining kidney is normal.

#### WOUNDS OF THE BLADDER

The bladder may be accidentally wounded in the course of operative procedures on neighboring organs such as abdominal or vaginal hysterectomy or plastic operations.

in the vagina. The bladder is occasionally found as a part of an inguinal or femoral hernia and has at times been wounded at operation. Other than operative trauma the bladder may be the seat of penetrating wounds such as from a stab or a bullet. More frequently however it results from a crushing injury often associated with fracture of the pelvic girdle. A severe abdominal contusion may result in a ruptured bladder particularly if the organ is distended at the time of the accident. The wound may be extraperitoneal or intraperitoneal or both.

**Symptoms**—Shock of varying degree is always present particularly in cases due to crushing accidents. As the patient rallies from shock attention will be directed to the bladder by bloody urine, pain and tenderness over the bladder, varying degrees of frequency, tenesmus and strangury or a complete inability to void. In extraperitoneal rupture these symptoms are followed very soon by all the signs of urinary extravasation and sepsis. In cases in which the rupture is directed into the peritoneal cavity there may be a temporary lull in the symptoms that is soon followed however by all the signs of intense and fulminating diffuse peritonitis and recurrence of profound shock.

**Diagnosis**—In any case of crushing injury or severe contusion of the pelvic region particularly if associated with any disturbance in the act of urination rupture of the bladder should be strongly suspected. If the patient is unable to void and catheterization is indicated this should be carried out under very strict aseptic precautions and the surgeon should be prepared to perform a suprapubic drainage at once if indicated. The writer does not approve of cystoscopy in these cases. An intravenous urogram may assist in establishing the diagnosis. If there is any doubt an exploratory operation is clearly indicated.

**Treatment**—The treatment may be summed up in the one word—*drainage*. This should be prompt and adequate. If the rent is intraperitoneal it should be closed, the peritoneal cavity freely drained with drains deep in the pelvis, the bladder drained extraperitoneally and the patient placed in the Fowler position. If the tear is extraperito-

neal the bladder and the perivesical area should be very freely drained. The perivesical area requiring drainage will usually have been converted into more or less of a distinct cavity by the extravasated urine.

### FOREIGN BODIES IN THE BLADDER

All manner of foreign bodies have been reported from time to time, as having been found in the bladder: splinters of bone from a fractured pelvis, bits of suture material or gauze drains, broken ends of catheters or drainage tubes, wax tapers, small lead pencils (the two latter often introduced by the patient for purposes of masturbation) etc. The diagnosis is established by the history (not always easy to obtain), the symptoms of frequent and painful urination, plus cystoscopic and roentgenographic studies. In the great majority of cases if an early diagnosis is made the foreign body can readily be removed by cystoscopic manipulation. If allowed to remain for any length of time a foreign body becomes covered by a deposit of urinary salts; it grows in size by accretion and it requires removal by means of suprapubic cystotomy. In other words it becomes for all practical purposes a vesical calculus.

### VESICAL CALCULI

Calculus of the bladder is one of the most ancient and venerable of all surgical diseases. Stones have been found in the bladders of Egyptian mummies. The subject has been discussed by all surgical writers beginning with the earliest periods recorded in history.

**Etiology**—The most commonly accepted theory of urinary lithiasis is that there is a disturbance in the colloidal content of the urine as a result of which the crystals are thrown out of solution. A deficiency of vitamin A in the diet appears to have some effect in reducing the necessary colloidal content of the urine. For a full and complete discussion of these phases of the problem the reader is referred to Joly's textbook on *Stone*. There are two other factors which predispose to the formation of stone in any part of the urinary tract, particularly in the bladder: effect on an obstruction to the normal current or flow of urine. Vesical calculi are noted far more frequently in males than in females owing to the fact that obstruction at the neck of the bladder in the urethra is noted much more commonly in the male. Many calculi are formed originally in the kidney from whence they are passed with accompanying colic to the bladder. While most of these stones are voided spontaneously if there is any obstruction to the flow of urine from the bladder

they remain and increase in size by accretion. This type of stone usually has a nucleus of calcium oxalate or uric acid with outer layers of calcium phosphate and carbonate. The majority of vesical calculi consist entirely of carbonates and phosphates and are formed originally in the bladder, usually in the presence of obstruction or infection or both. Any foreign body introduced or left in the bladder by accident will in time become encrusted with a layer of urinary salts and will become a calculus.

**Symptoms.**—The outstanding symptom of calculus of the bladder is frequency of urination, worse by day and when the patient is moving about. This is in rather sharp contrast with urinary frequency in cases of renal or vesical tuberculosis, which is worse at night. Urination is frequently painful, and often there is a tendency for the stream to start and stop several times during the act. *Bloody urine* is often noted, occasionally in the form of a gross hematuria with blood intimately mixed with the urine more fre-

the bladder. Very large calculi may occasionally be palpated via the rectum or vagina, rarely even suprapubically. The diagnosis should always be confirmed by cystoscopic investigation, which is readily and easily accomplished. Large and perhaps even small calculi will show in roentgeno-

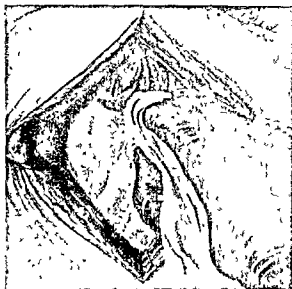


Fig. 652.—The bladder is exposed and is readily recognized by its large veins and decussating muscle fibers. The peritoneal fold is being stripped back.

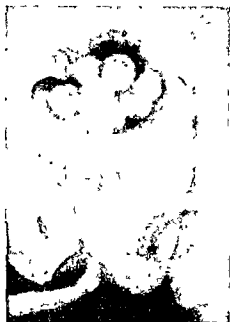


Fig. 651.—Multiple vesical calculi also showing urethrogram and large prostate. The calculi were removed by suprapubic cystotomy, followed later by suprapubic prostatectomy.

quently in the form of a terminal hematuria. Microscopic examination almost invariably shows red blood cells, together with pus in varying amounts.

**Diagnosis.**—The diagnosis is strongly suggested by the very characteristic symptoms. Occasionally the grate of a calculus may be felt when a catheter is passed into

grams (Fig. 651). It is to be noted however, that a negative roentgenogram does not exclude the presence of vesical calculi. This may be accounted for by the low density of the calculi or their situation behind the pubic bones so as to obscure the picture.

**Treatment.**—Stones which are not too large or too numerous may be removed transurethrally by means of crushing and evacuation with the Bigelow evacuator. Multiple stones or single stones exceeding an inch in diameter should be removed by suprapubic cystotomy. Crushing or litholapaxy, until recently, was always done with a Bigelow lithotrite. In the hands of an expert it is a very safe and reliable instrument, and many operators even today still employ it as a matter of preference. Most urologists, however, at the present time prefer to crush the stone under direct vision using one of the many cystoscopic lithotrites in common use. Whichever instrument is used, sacral or transsacral novocain provides the ideal anesthetic. The writer feels that all these patients should be hospitalized

for a few days. One should proceed methodically and patiently with repeated crushing and washing until it is assumed that every vestige of calculus has been removed. This should be confirmed by cystoscopic inspection. While small particles may be evacuated spontaneously, their continued presence may provide the nucleus for a recurrence.

All large and multiple calculi are best removed by means of suprapubic cystotomy. This is easily carried out under local or field block anesthesia. The bladder is irrigated and distended with some bland solution such as 2 per cent boric acid. A 3 inch midline incision just above the symphysis is carried through the various layers of the abdominal wall down to the bladder which is easily recognized by the large veins and decussating muscle fibers. The peritoneal fold is stripped back and the bladder opened and evacuated through a small incision near its summit. This incision may later be enlarged if the size of the stone demands it. The stone is removed and the bladder carefully investigated by touch and sight for any complication such as tumor, diverticulum, obstruction of the neck, etc. If there is an obstruction at the neck of the bladder such as an enlargement of the prostate it is well to correct this at a later date. Otherwise calculi are apt to re-form. If the bladder has not been grossly infected and the vesical wound has not been too badly traumatized by the removal of a very large calculus, primary union may be attempted by closing the wound tightly with interrupted chromic sutures. In this event an indwelling catheter should be left in the urethra and a cigaret drain in the space of Retzius. If successful this of course shortens the period of convalescence. However in the great majority of cases it is wiser to leave a rubber tube in the bladder for drainage. This may be removed at the end of a week following which the sinus will heal promptly provided there is no obstruction to urination.

#### ULCER OF THE BLADDER

Vesical ulcers are rather frequently noted as an expression of other forms of underlying pathology such as severe forms of cystitis, vesical tuberculosis, sloughing carcinoma, etc. These are best considered under their respective headings.

The two types of ulcer most frequently noted as separate and distinct pathologic entities are radium burns and the so-called elusive ulcer first described by Hunner.

**Radium Burns**—Radium burns occur not infrequently following the use of large doses of radium for vesical neoplasm or even small doses in very susceptible persons. The symptoms are frequency, dysuria and occasional hematuria.

**Diagnosis**—It is obviously of vital importance to differentiate between a radium burn and extension or persistence of a sloughing carcinoma, yet it is often an extremely difficult diagnosis to make. In both instances the cystoscopic picture may be that of a dirty gray sloughing, slightly elevated area. Biopsy specimens obtained with a cystoscopic rongeur forceps may be helpful. If the specimen obtained definitely shows carcinoma the diagnosis is of course established. However a negative finding does not definitely exclude carcinoma. If there is any doubt it is well to withhold the further use of radium and keep the patient under careful cystoscopic observation for a few months. The appearance of a radium burn will remain about the same whereas a neoplasm will show a gradual extension and growth.

**Treatment**—There is no specific treatment. The condition is very obstinate and may persist for months or years. In the meantime the bladder should be kept as clean as possible by frequent lavage with some bland solution. This is done in part for the purpose of relieving the symptoms and in part to prevent the formation of calculi resulting from the precipitation of urinary salts on the ulcer base. Cystoscopy should be performed at fairly frequent intervals in order to determine the progress of the case and the presence of complications such as calculi or recurrence of the neoplasm. Occasionally it may be necessary to perform a suprapubic cystotomy for the purpose of putting the bladder at rest and obtaining large biopsy specimens in doubtful cases. On the whole they are extremely obstinate and difficult cases to handle.

**Elusive Ulcer**—Elusive ulcer which was first described by Hunner is a very definite pathologic and clinical entity. While its exact nature has not been demonstrated it

is generally supposed to be a metastatic streptococcus invasion of the submucosa of the bladder with resulting round cell infiltration and fibrosis. While there may be only a very tiny area of superficial ulceration this will often be surrounded by an extensive induration and marked thickening of the entire vesical wall. These areas may be single or multiple. The ulcers will often heal over temporarily only to break out in another place. The vast majority of these lesions occur in women.

**Symptoms**—The symptoms consist of marked frequency both by day and by night and severe pain referred to the suprapubic area and urethra markedly increased by even slight distention of the bladder. The patient may for one reason or another (drugs) sleep soundly for a few hours and be awakened by very severe pain which will be partly relieved by urination. Dysuria is not ordinarily a symptom. On the contrary, voiding often gives some relief.

**Diagnosis**—It is not always easy to make the diagnosis. When seen cystoscopically the ulcer appears as a tiny red spot surrounded by an area of congestion with dilated vessels. By careful observation rigidity and lack of pliability of the vesical wall will be noted. These findings may be observed at the first cystoscopic examination. Often however the condition is missed at the first examination only to be revealed later hence the term elusive ulcer. Repeated cystoscopic examination may show the lesion at one time in a certain area and at a later examination it may be healed and a similar lesion noted in another part of the bladder. The urine is usually crystal clear may show no abnormal elements under the microscope and may be sterile to ordinary cultural methods. However repeated careful examinations will usually show a few red blood cells and careful cultures may reveal a short chain streptococcus.

**Treatment**—This disease is extremely obstinate and may be wholly intractable to any form of treatment. One should hunt carefully for possible remote foci of infection and remove them. The writer has seen one case apparently cured following the removal of an infected tooth and tonsils. Short chain streptococci were demonstrated in the urine and also in the tooth and tonsils removed.

Santal oil administered internally occasionally affords some slight measure of relief. The writer has in a few cases obtained very definite results from the intravenous use of neocarsphenamine. Temporary relief sometimes lasting for weeks or months will occasionally follow forcible dilation of the bladder or light fulguration of the ulcer under anesthesia preferably spinal. Hunner has noted that these cases are frequently associated with bilateral ureteral strictures and that relief is often afforded by dilation of the strictures. Wide resection of the ulcer bearing area always affords relief for a time. However this operation which is one of considerable magnitude is rarely if ever justified since recurrence almost invariably occurs. In a few of the most severe and obstinate cases which have resisted all other forms of treatment if the patient's general condition warrants such a formidable procedure one may consider total cystectomy with transplantation of the ureters into the bowel.

There is a great temptation in all of these cases to resort to the use of opiates but the greatest care should be exercised since the patient will require increasingly larger doses and a habit is quickly formed.

N. P. RATIMUS

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#### DIVERTICULA OF THE URINARY BLADDER

Two types of out-pouching of the bladder occur: *sacculi* and *diverticula*, differing not only in size but in clinical significance. *Sacculi* are present in every case of high grade obstruction of the lower portion of the urinary tract, are smaller than the tip of the adult finger (1 cm. in depth) and recede when the obstructing agent is removed. *Diverticula* are larger in size and often re-

quire surgical treatment Vesical diverticulum is almost exclusively a disease of males It is occasionally encountered in boys and young men but nearly all of the cases occur in men over 40 years predominantly after 60 years, the age when obstruction is common

A diverticulum of the bladder like all hernias or diverticula in other organs occurs as a result of increased intravisceral tension or of weakness of the wall or both In nearly

and adhesions anchor the sac firmly to the surrounding tissues of the pelvis

The fundamental defect in diverticula is the absence of muscle in the wall weakness of vesical muscle is an essential predisposing factor and what contractile elements remain are so dispersed as to be functionally ineffective Since diverticula do not contract high grades of stasis often occur because of their presence leading to retention of crystals, with stone formation or, when infected

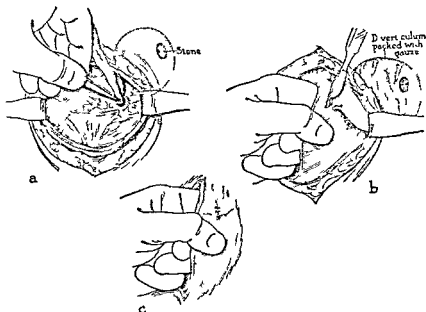


Fig 653.—Treatment of diverticulum of the bladder *a* The bladder has been opened and the diverticulum is being packed with gauze The shaded area represents the extent of the diverticulum which contains a stone *b* excision of the diverticulum from the outer surface of the bladder *c* closure of the bladder wall from the outside

every case vesical diverticulum occurs only as a result of urinary obstruction and thus is a *secondary lesion*

**Surgical Pathology.**—While vesical diverticula may form in any part of the bladder, nearly all of them originate at the junction of the trigone and the detrusor, the classical site is lateral to the ureteral meatus, while occasionally the ureter itself opens into the sac It is usually bilaterally symmetrical A diverticulum often grows to a size considerably larger than that of the bladder itself developing on its postero-lateral aspect deep in the pelvis occasionally it lodges and becomes irreducible in the sac of an inguinal hernia Very often the diverticulum is loosely attached to the surrounding tissues so that it may be enucleated by blunt dissection less often peridiverticulitis

to putrefaction of the urine

**Clinical Picture.**—The vesical diverticula result in retention in the sac and therefore in the bladder A diverticulum as such produces no symptoms, its effects are manifested in protracted cystitis or in difficulty in emptying the bladder It should be suspected in any male with pyuria and vesical retention Most patients with vesical diverticulum as a result of prostatic obstruction are found on rectal examination to have a prostate which is small or only moderately enlarged (median bar formation), the prostatic hypertrophy may be large but this is less usual

Often the presence of a diverticulum is first suspected after an unsuccessful prostatectomy, if suprapubic prostatectomy has been done the incision will fail to close if

transurethral prostatectomy was performed the patient may be unable to urinate. When a diverticulum is irreducible in inguinal hernia the patient must manually compress the scrotum to urinate.

Putrefaction of urine in a diverticulum is one of the three causes of a nauseatingly foul smelling urine (the others being pyonephrosis and a vesicocolic fistula).

**Diagnosis**—To be forewarned is to be forearmed is never more true than in the treatment of obstruction due to prostatic causes with reference to diverticulum. The urologist must always have diverticulum in mind when studying patients with prostatic obstruction if it should be overlooked the prostatectomy is apt to be a failure. It should also be thought of in the presence of pyuria with vesical retention in the male.

The diagnosis is made by two methods: cystoscopy and the cystogram. At cystoscopy a grayish dark cavern is seen in the region of the ureter or lateral to it. A *cystogram* is a roentgenogram taken after filling the bladder with a contrast medium such as 5 per cent solution of diodrast or sodium iodide. Sodium iodide is an electrolyte is irritating and must be evacuated after the x-ray is taken. A cystogram taken with the patient in a lateral position is often of help in making a diagnosis. The interpretation of cystograms is sometimes puzzling when the diverticulum is large and one is faced with the dilemma—which sac is bladder and which is diverticulum? The problem is easily solved by remembering that a diverticulum containing no muscle must have a smooth outline contrariwise the bladder being obstructed is irregular in outline from sacculi. A further x-ray sign is the presence of laminated urinary calculi in the bladder region with absence of stones in the bladder at cystoscopy; they may well be in a diverticulum.

**Treatment**—In a minority of cases the diverticulum recedes spontaneously and spectacularly when lower urinary obstruction is removed by open or transurethral prostatectomy. Most diverticula however must be removed surgically. An unequivocal indication for operation is the presence of residual urine after the obstruction has been removed although usually it is not wise to delay the excision to this point. Practically it is best to excise a large diverticulum when

drainage is not dependent proceeding at a subsequent operation with suprapubic prostatectomy when the diverticulum is small transurethral prostatectomy may well be done with diverticulectomy later if residual urine persists. Enlargement of the mouth of a diverticulum by transurethral resection is not often followed by good results.

Technically a diverticulum is approached through a midline suprapubic incision after distention of the bladder with fluid; it is unnecessary to open the peritoneal cavity. The sac is mobilized as much as possible extravesically before the bladder is opened. The orifice of the diverticulum is exposed and the neck of the sac is then transected and closed with sutures of catgut; the fundus of the sac is then removed. At times it is helpful to open the bladder and insert a finger in the diverticulum to define its limits more accurately; also the sac may be packed with gauze to make it more solid. A soft rubber drain is placed extravasically to avoid a burrowing abscess. In the rare instances where a ureter opens into the diverticulum it must be reimplanted in a new place in the bladder—the *ureterocystoneostomy* of Al barran.

A small diverticulum may be approached through the open bladder inverted by attaching a forceps to the wall of the fundus of the sac amputated and sutured transversally. Operations on vesical diverticula give gratifying results.

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## CALCULI OF THE KIDNEY AND URETER, STRICTURES AND KINKS OF THE URETER

### CALCULI

*Calculus stone and gravel* are the terms applied to deposits of crystalline substance in the upper urinary tract. *Urinary calculi* are of two main types: (1) those formed in alkaline urine (phosphate and carbonate stones) and (2) those formed in acid urine



(uric acid urate cystine and the rare xanthine stones)

Stones may form at any age but the majority occur in patients under forty years of age. The writer has seen a small collection of shot like calculi in the kidney of a three week old baby removed at autopsy. In another case stones in the bladder left ureter and left kidney of an eighteen month old boy were removed by operation. The oldest patient suffering from renal calculi in the writer's series was eighty six years old and the proportion of males to females was approximately 3 to 2.

**Etiology**—Among the many etiological theories that have been advanced for the formation of urinary calculus are colloid crystalloid imbalance stasis infection vitamin A deficiency disturbance of calcium phosphorus metabolism due to hyperparathyroidism heredity racial predisposition and climate. Urinary stone rarely occurs in the absence of obstruction and infection. In recent years many cases of urinary calculi due to the administration of the sulfonamide drugs have been reported. Such calculi occur much more readily in an acid than in an alkaline urine.

**Pathology**—A kidney which harbors a calculus is always damaged thereby. Stone causes obstruction and this results in dilatation of the pelvis and calices and additional opportunity for the growth of bacteria with the accompanying toxicity which affects the patient generally as well as locally. Per sized calculi that become wedged in the ureter cause more general as well as local disturbance than larger calculi which remain in the kidney. Calculous anuria is rare. When it does occur it usually follows operation cystoscopy or other traumatism and is often fatal.

**Symptomatology**—Pain is usually the symptom which causes the patient to seek medical aid. This may be a dull ache in the affected loin but more often is colicky in nature. The agonizing pain of acute renal colic can be controlled only by morphine or one of its derivatives. The discomfort attendant on obstruction due to calculus in the upper urinary tract depends on the location of the stone and the degree of blockage. Partial obstruction at the ureteropelvic junction will cause a more or less constant ache

in the back between the crest of the ilium and the costovertebral angle. If obstruction is complete there will be intense colic. The patient feels as though his loin were being compressed in a vise. If obstruction is low down in the right ureter the pain may often be mistaken for irritation of the appendix. Frequently the pain radiates downward into the testicle or labium on the affected side. *Emating* occurs often in severe renal and ureteral colic. *Hematuria* either microscopic or more often macroscopic occurs in almost every case of stone. This is not constant and may pass unnoticed for years. *General debility* and even *uremia* may occur in long standing extensive cases of renal calculi. These are late manifestations however and some very large calculi may exist for a long time without their appearance.

**Diagnosis**—Roentgenography is of the greatest assistance in the diagnosis of stone in the upper urinary tract. Approximately 10 per cent of the calculi usually acid in type do not show in a plain x ray. Urography by the retrograde and intravenous method then becomes of paramount importance in making the diagnosis of calculus by means of filling defects. When these methods fail it is often useful to pass a wax tipped catheter. If the tip becomes scratched the diagnosis may be positively made even if the presence of a calculus is not made out by other methods. Extraordinary shadows may often be confusing because of their proximity to the upper urinary tract. A pyelogram will usually indicate the true location of the confusing shadow. When the obstruction is on the right side high up in the ureter or at the ureteropelvic junction the symptoms may be mistaken for those of cholecystitis and when low down on the right side for those of appendicitis or in the female of oophoritis. Urography and careful examination of the urinary specimens will clarify the situation in most instances.

**Prognosis**—The outlook for a patient suffering from renal or ureteral calculus is on the whole favorable. Many stones pass unaided and the majority of the others will pass with a little assistance on the part of the urologist. Calculi of the upper urinary tract are looked on as being very painful but rarely fatal. The nature of the discomfort is such that it cannot be disregarded

It drives the patient to seek medical aid early and induces him to undergo any amount of necessary treatment to avoid a recurrence of the symptoms

**Treatment—Symptomatic**—Two principles are involved in the successful treatment of renal and ureteral colic—sedatives and heat. The agony of a patient with renal colic causes such rigid contractions of the musculature of the entire body and such tight constriction of the affected viscus that the obstruction to the urinary outflow is increased and the back pressure becomes more

such a caliber that the stone will not meet with too much obstruction. This is accomplished by passing many bougies beside one another by means of the Dourmashkin bag or by the wax bulb method of Hunner. The author uses all of these methods on occasion but ordinarily prefers the multiple bougies. One may persist for weeks in an endeavor to have stones pass if the patient does not have unbearable uncontrollable pain for long periods of time. If fever and other evidences of toxic absorption develop or if the patient is intolerant to cystoscopic manipu-

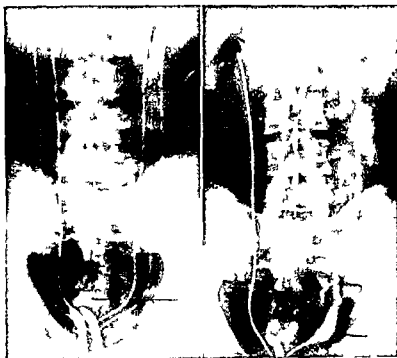


Fig 64

Fig 65

Fig 64—Roentgenogram showing a double exposure with the x-ray tube shifted. The shadow shifted exactly with the catheter thus proving that there was a calculus present in the ureter. If there had been a discrepancy in the two shadows it would have indicated that the shadow was on a different plane from that of the ureter.

Fig 65—There was a filling defect in the medium at the site of the shadow shown in the previous figure. This calculus passed after dilation and was removed from the bladder with the rongeur designed by the author.

marked therefore morphine in  $\frac{1}{4}$  grain doses is the drug of choice. If the discomfort is moderate codeine in 1 grain doses is advisable. If sedatives are not immediately available or are contraindicated great temporary relief will be obtained by putting the patient in a very hot bath. If the obstruction causes only backache a hot pad or hot water bottle applied to the affected loin will be comforting.

**Non Operative Treatment**—Small calculi may be induced to pass from the kidney through the ureter by dilating the ureter to

allow operative intervention may be necessary.

**Dissolution of Calculi by Chemical Means**—The writer has been able to dissolve newly formed phosphatic calculi (usually post-operative recurrences) in some instances by means of the following solution:

Magnesium oxide and iron	651 Gm
Citric acid 1 H <sub>2</sub> O	325 Gm
Sterile distilled water to make	1000 cc
Boil the solution 1 hour then cool. Boil another hour and then cool. Make up to 1000 cc with sterile distilled water.	

If a nephrostomy tube is still in place through and through irrigation is employed otherwise the renal pelvis is usually irrigated through a no 5 F catheter and drained through a no 8 or 9 F catheter

**Operative Treatment of Renal Calculi**—Removal of calculi from the renal pelvis may be accomplished by means of *polarotomy* or *nephrotomy* if the stones are large or deeply disposed. The operation of choice is



Fig 656—A large stone is being removed from the pelvis of the kidney through a nephrotomy. A nephrostomy tube is in place. The lower pole of the rib cage is also in place.

the following procedure developed by the author by means of animal experimentation

An incision is made from the costovertebral angle downward and outward about 2 cm below the costal margin. This is deepened through the subcutaneous tissue, superficial fascia, muscular layers and the deep fascia care being taken not to excise the lower branches of the twelfth subcostal or the iliohypogastric nerves. The costovertebral fascia may be incised. This will allow the twelfth rib to swing up making resection of a rib unnecessary in most instances. The incision into the kidney is usually made in either the upper or the lower pole preferably on the lateral convex border. Almost any stone can be removed through a polar incision and this type of wound is more easily repaired than a central cortical incision. Ribbon gut is fixed in

position by being passed through the fibrous capsule on the anterior and posterior surfaces. An incision is made into the cortex between the two capsular strips. The calculus is located and removed. A drainage tube is inserted through the wound into the pelvis. A piece of fat is placed in the wound for hemostasis and the ends of the ribbon gut are tied over it with just enough pressure to approximate the wound edges. The kidney is replaced in its bed. Penrose drains are placed down to the nephrostomy and the wound is closed. The nephrostomy tube is held in place at the posterior angle of the wound by a suture passed through the ribbon gut.

*Resection of a dependent or constricted calyx* is sometimes indicated in order to prevent recurrence following removal of a stone since such calyces are especially favorable media for stone formation.



Fig 657—The ribbon gut is placed with the knot tied away from the wound in the kidney. A small piece of fat is sutured on the surface of the incision through the cortex of the kidney. A tube is placed in the pelvis and fixed in position by a catgut strand passed through the edge of the ribbon gut.

**Operative Treatment of Ureteral Calculi**—An incision is made in the nipple line extending from a point just below the costal margin down to a point in front of the anterior superior spine of the ilium. If the calculus is in the lower end of the ureter the inferior portion of the incision is turned toward the midline across the rectus muscle which with its sheath may be divided partly or entirely across. This incision is deepened through the superficial fascia, muscular

layers and deep fascia and the peritoneum is carefully separated from the skeletal wall. The latter and its contents are pulled to ward the midline with large retractors protected by abdominal pads. The ureter is identified best as it crosses the bifurcation of the iliac vessels. It is isolated from the peritoneum to which it clings tightly in this area and followed to the point at which the stone rests. It is well to milk the calculus up to a point above its resting place because there is always a constriction at the point of impaction with a dilatation above it. The ureter is incised and the calculus is grasped with special forceps and removed. A flexible probe is inserted into the ureter to dilate it. A single catgut stitch passed through the wall of the ureter but not into its lumen closes the incision. The wound is closed in layers with ample Penrose drains. Catgut is used for the muscular and fascial repair and tension sutures for the skin.

After three or four days the drainage of urine through the wound stops and the drains may be removed. Dilatation of the ureter after ureterotomy is absolutely necessary; otherwise a stricture will develop at the site of the incision because of the isolation of the ureter and incision into it, all of which is bathed in infected urine. There is no agency more potent in laying down scar tissue than infected urine; hence the necessity for postoperative dilatation.

**Prevention of Recurrence of Calculi.**—Prevention of the recurrence of calculi is a most important part of the postoperative care and may be accomplished as follows:

1. Every possible obstruction to the urinary outflow should be eliminated.

2. Infection should be treated by ureteral and renal pelvic irrigations of uroflavine 1:2000 or uroanal dectrose 1:2000 and by internal medication in the form of methenamine and acid sodium phosphate (in divided doses of 60 grains or more of the former daily and enough of the latter to keep the urine acid) or one of the sulfonamide drugs (10 to 20 grains three times a day and then less). Treatment with sulfonamides should not be continued indefinitely.

3. The reaction of the urine should be changed. If acid calculi have been removed the urine should be kept slightly alkaline and vice versa. To this end alkaline ash

diets and acid ash diets are utilized. If the alkaline diet is not effective the patient should be given sodium bicarbonate or sodasun by mouth and urged to take alkaline waters, a very good domestic one being Karik water. If acidification is desired sodium benzoate and sodium phosphate or ammonium chloride may be found helpful in addition to the acid ash diet. It is advisable to augment both the acid ash and the alkaline ash diet with the administration of vitamin A in the form of haliver oil capsules, carotene in oil etc.

### STRICTURE OF THE URETER

**Etiology.**—Stricture of the ureter may be congenital or acquired. Congenital strictures are usually exaggerations of the normal anatomical points of narrowing in the ureter without infection. Acquired strictures are caused by infection either within or outside the viscus. Hunner claims that metastatic infection may originate in the tonsils and be deposited in the wall of the ureter resulting in narrowing. The tubercle bacillus is responsible for stricture of the ureter in most cases of long standing. Chronic irritation and the resulting inflammatory reaction result in the laying down of fibrous tissue and the lumen of the ureter gradually becomes occluded. Another source of ureteral occlusion or semi occlusion is inflammatory reaction around the ureter due to disease in a neighboring structure usually a lymph gland. The intramural portion of the ureter is often narrowed as a result of chronic cystitis. Stricture may follow ureterotomy for stone. The ureter in such an operation is isolated and incised, allowing it to be surrounded for a considerable time by infected urine and producing an intense inflammatory reaction.

Stricture of the ureter occurs frequently but it is not so common as some enthusiasts would have us believe.

**Symptoms.**—These vary in intensity from slight frequency of urination and dull backache to the most intense renal colic.

**Diagnosis.**—Diagnosis is made by two methods. The most useful in the author's hands is the pveloureterogram accomplished by injecting a non irritating non toxic opaque substance such as neo iopax into the suspected side by means of a ure

teral catheter and taking a roentgenogram preferably with the patient in an erect or semi erect posture. Serial pyelograms are especially useful (The intravenous urogram is also satisfactory). The other method consists of passing a catheter with a wax bulb into the ureter and observing the so-called ureteral hang when the bulb engages in the narrowed part of the ureter. Confusion of stricture with stone in the ureter which may give identical symptoms is usually avoided by the fact that the stone is often demonstrable in a roentgenogram.

**Prognosis**—This depends largely on the etiology of the stricture. A narrowing caused by the tubercle bacillus is best treated by removing the kidney above it provided the other kidney is competent. On the whole the outlook for a patient suffering from stricture of the ureter is favorable and the discomfort will often be relieved by the mere passing of a No. C F catheter for the purpose of examination.

**Treatment**—Symptomatic treatment consists of internal medication to relieve the burning urination which often occurs. In a mild case the patient may be given the following every four hours with great relief:

Tincture hyoscyamus	℥j
Potassium citrate	℥j
Water	3vj

Sig—j every four hours in water

In cases of severe pain in the back codeine in  $\frac{1}{4}$  or 1 grain doses may be required and in severe renal colic morphine should be given hypodermically. Hot applications and very hot baths often are comforting.

Cystoscopic treatment is the most important therapeutic measure in the care of a patient suffering from stricture. Dilatation of the narrowed duct is best accomplished by passing bougies of increasing sizes. Bougies may also be passed simultaneously so that two or even three are utilized to enlarge the lumen to a diameter corresponding to that of a No. 23 or 24 F catheter.

Operative measures are often important in the treatment of stricture. Such procedures usually are necessary at the uretero-pelvic junction and consist in the removal of any extraneous influences such as aberrant vessels or adhesive bands and various

plastic operations. The two that the writer has found most useful are the Foley's plastic and ureteropelvic anastomosis (reimplantation of the ureter into the most dependent portion of the pelvis after resection of the strictured area). Prolonged nephrostomy drainage and ureteral splinting (six weeks) are of prime importance in ureteropelvic surgery.

### KINKS OF THE URETER

**Etiology**—There are two causes for kinks in the ureter. The more common is *nephroptosis*. The other less common is



FIG. 658.—Tissot's pyelogram showing a kink and stricture of the right ureter with slight hydronephrosis above it. The patient had had two major operations for the relief of the accompanying right-sided pain and was about to have another one. Elevation of the kidney by means of a belt and dilatation of the ureter effected a cure.

*hydroureter* due to obstruction of long standing at the lower end of the ureter or even at the vesical outlet.

**Pathology**—The ureter is always enlarged above the site of the kink and there is usually considerable narrowing of the ureter at this point.

**Symptoms**—There is always pain in the back on the affected side. Occasionally colic

# TUMORS AND CYSTS OF THE KIDNEY AND URETER

may be intense and there is usually urinary frequency

**Prognosis**—When the kink is due to nephroptosis proper treatment of this condition will almost invariably bring relief unless there is also entropsis in which case the outlook is not good. When the condition is secondary to lower ureteral or bladder neck obstruction ureteral dilation will usually prove satisfactory unless the dilation and elongation causing the kinking are considerable or the loops are matted together.

**Treatment.**—*Symptomatic Treatment*—Symptomatic treatment is accomplished by various means designed to restore the ptosed kidney to its normal position. When the kidney is in its proper place the ureter will straighten out and the kink will be relieved allowing proper drainage. The simplest method of accomplishing this is to apply a properly fitted belt supplied with a pad or pads for exerting pressure on the lower pole of the kidney and restoring it to its proper place. This belt should be applied with the patient lying on the back and should be tightened from below upward. At night the patient should sleep with the foot of the bed elevated. In severe cases the pain must be relieved by sedatives.

*Cystoscopic Treatment*—The strictures resulting from longstanding kinks of the ureter must be dilated with bougies.

*Operative Treatment*—Nephropexy or sewing up of the kidney is sometimes necessary to reduce nephroptosis. This may be accomplished by the author's ribbon gut suspension method.

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## TUMORS AND CYSTS OF THE KIDNEY AND URETER

New growths of the kidney are fairly common but nevertheless of great importance because they are very deadly and but the only hope for improvement in the results of treatment lies in early diagnosis. Malignant tumors of the kidney constitute about 0.3 per cent of all urological and about the same percentage of all renal tumors in adults. While malignant tumors are much rarer in children yet first decade the kidney furnishes one every five and more than any other organ of the body.

**Pathology**—*Neoplasms*—**HYPERNEPHROMA**—Hypernephroma (nephroma, sarcoma, hypernephroma, endothelial clear cell epithelioma, perithelial angiosarcoma) is the commonest tumor of the kidney. It is usually called a hypernephroma because it resembles microscopically the renal tissue of the adrenal gland. There is no definite proof however that it is from misplaced bits of adrenal tissue. The tumor may arise in any part of the cortex a little more frequently in the pole. It is enclosed by a capsule so that it does not invade the renal tissue but it is set aside and causes pressure absorption. It does tend to invade the renal pelvis, forming small or large processes into it and sometimes filling it completely. It may invade the renal vein, sending processes into it which may extend to the vena cava, even the heart. Some believe the tumor to be benign in its early stages but it has possibilities of malignancy. In the early cut surface is opaque, has a yellow tint and is varied by areas of necrosis, red or brown areas of hemorrhage and red spots due to blood filled cysts. The blood supply of the kidney is increased. The capsular vessels may be dilated. Microscopically the typical cells have small nuclei and the cytoplasm is glandular, distended by droplets of lipid material which appears clear and does not stain with ordinary stains. These cells usually are solid alveoli but the alveoli may be dilated and the cells often contain blood. They are sometimes distended into good sized cysts containing fresh or old blood.

**PAPILLARY CYSTADENOMA**—This tumor is also encapsulated but is characterized by cyst like cavities filled by enormous numbers of fine branching papillae. The cysts never communicate with the pelvis. The walls and papillae are covered with one layer of cuboidal epithelium.

**CARCINOMA AND ADENOCARCINOMA**—Some renal tumors are made up of cells which are grouped in alveoli but do not have the clear distended cytoplasm which is characteristic of hypernephroma. The alveoli may or may not have lumens if they have the tumor is called an adenocarcinoma. There may also be a failure of encapsulation with strands and cords of tumor cells invading the renal tissue. Such tumors are often called carcinoma of the kidney but this classification is indistinct and there is much dispute among pathologists as to what tumors should be assigned to it.

In fact little is known about the histogenesis of all these tumors and all three microscopic types may occasionally be found in a single tumor mass. They all have many gross characteristics in common the most important of which is invasion of the renal pelvis causing the filling defects which are demonstrated by means of pyelography.

Cortical renal tumors usually metastasize first to the lungs sometimes to the suprarenal gland later to any organ of the body. The metastases may be quite unlike the primary tumor histologically.

**SARCOMA**—Sarcoma of the kidney is rare. It may arise in the kidney or in the neighboring retroperitoneal tissue. There is no capsule and the renal tissue is freely invaded in all directions so that there is no characteristic pelvic deformity. Other tissues and organs also may be invaded and bound into one mass with the kidney. Rarely lymphosarcoma may invade the kidney. The growth characteristics of sarcoma make successful surgical treatment almost impossible.

**EMBRYOMA**—The embryomas include Wilms mixed tumor leiomyosarcoma rhabdomyosarcoma myxosarcoma chondrosarcoma adenosarcoma teratoma dermoid etc. Most of the tumors of the kidney which occur in infants are embryomatous but embryomas

occasionally occur in adults. These tumors may arise in the kidney itself in the connective tissue of the hilus or in the perirenal tissues. They may compress the kidney from the outside or may expand it by growing from within. In the gross they are usually found to be smooth and not adherent to the surrounding organs but their attachments in the retroperitoneal tissues are often very extensive making surgical removal difficult. Hemorrhage and necrosis are rare. Metastases do not occur unless carcinomatous or sarcomatous degeneration has taken place which happens in from 20 to 35 per cent of cases. The tumors nevertheless may cause death from local recurrence after surgical removal. The rate of growth often shows a sudden dramatic increase. As there is no tendency to intrapelvic growth there is no characteristic pelvic deformity and hematuria is rare though it may occur. Microscopically there is usually an abundant connective tissue stroma of embryonic type beset with renal or tubules lined with epithelium. The stroma may be myxomatous (gelatinous). Frequently completely differentiated tissues are found such as smooth and striated muscle cartilage intestinal mucosa etc. Rarely there is an actual dermoid cyst with skin hair teeth etc.

**PAPILLOMA OF THE RENAL PELVIS AND URETER**—The epithelium of the renal pelvis and ureter is exactly like that of the bladder so that papillary tumors may arise which are exactly like papillomas of the bladder. These growths villous and branching in character are benign and form masses projecting into the lumen of the pelvis or of the ureter. They may be single or multiple sometimes with hundreds of separate tumors. Multiple tumors are more apt to be malignant. Implantation may occur to any point in the ureter or bladder below the original tumor therefore papilloma of the pelvis must be suspected in every case of papilloma of the bladder.

**PAPILLARY CARCINOMA OF THE RENAL PELVIS AND URETER**—Like papilloma of the bladder papilloma of the kidney pelvis may take on malignant characteristics. The malignant cells invade the renal tissue so that in the later stages the pelvic origin may not be apparent. Necrosis and ulceration may develop and adjacent organs may be in-

vaded Metastasis may occur to any organ as in carcinoma of the bladder

**LITHIELIOMA OF THE RENAL PELVIS AND URETER**—Epithelioma must be preceded by metaplasia (leukoplakia) of the renal or ureteral epithelium which is usually caused by chronic infection sometimes by calculi The epithelioma may be either basal cell or squamous cell Like all others of its type it invades all tissues indiscriminately and ulcerates early It may obstruct the ureter causing hydronephrosis There is no characteristic pelvic deformity Metastasis is fairly late and may occur to any organ This tumor is practically never diagnosed in time for effective treatment

**ANGIOMA OF THE KIDNEY**—Hemangiomas are usually small They may lie in any part of the kidney and give no symptoms unless they are in contact with the pelvic mucosa when they may occasion severe hemorrhage when they may occasion severe hemorrhage out of proportion to their size

**METASTATIC TUMORS OF THE KIDNEY AND URETER**—Metastases in the kidney are rare perhaps offshoot from tumors of the opposite kidney next from tumors of the uterus and less frequently from tumors of the prostate stomach and breast Severe perirenal hemorrhage may occur Metastases to the ureter are even rarer When present they are usually from tumors of the bladder or prostate and always cause obstruction and hydronephrosis

**Cysts**—**SIMPLE CYST OF THE KIDNEY** (*Serous Cyst Solitary Cyst*)—A simple cyst is not a neoplasm but may cause great enlargement in the region of the kidney The condition is comparatively uncommon The cyst occurs a little more frequently at the lower pole than at the upper or in the midportion There is no fibrous capsule the cyst lies in direct contact with the parenchyma and is lined with a thin simple layer of epithelium The contents are clear and transparent and may contain an excess of urea like urine The pathogenesis is unknown The cysts vary in size from those which are a few millimeters in diameter to those which can hold as much as 10 liters

**HEMORRHAGIC CYST OF THE KIDNEYS**—Sometimes the contents of a renal cyst are bloody Excluding blood containing cystic spaces in malignant tumors there are three

theories for the development of a hemorrhagic cyst (1) an entity of unknown pathogenesis (2) arising from an aneurysm of an intrarenal artery and (3) hemorrhage from the erosion of a blood vessel into a serous cyst

**EXTRARENAL CYSTS**—Occasionally extrarenal cysts some of them very large are seen They are thought to result from traumatism and probably follow reorption of hematomas The walls are composed of fibrous tissue often with heavy deposits of calcareous material so that the outline can be clearly seen in roentgenograms

**POLYCYSTIC KIDNEYS**—Polycystic kidneys are congenital and always bilateral The kidneys contain large numbers of thin walled cysts thought to be the result of obstruction of the renal tubules or of occlusion following their failure to unite with the collecting tubules in embryo The cysts gradually increase in size causing anemia and absorption of the normal renal tissue between them so that death from renal insufficiency usually occurs at about the age of fifty The pelvis is distorted and elongated

**Miscellaneous**—**ANEURYSM OF THE RENAL ARTERY**—This is a rare condition which is usually indistinguishable clinically from a tumor of the kidney causing mass pain and hematuria It may be a true aneurysm or a false or dissecting aneurysm

**ECHINOCOCCUS CYST OF THE KIDNEY**—Echinococcus cyst (hydatid cyst) is a disease which may involve the kidney sometimes forming a renal tumor The cyst may rupture into the pelvis or into the peritoneum Obstruction with hydronephrosis may be caused

**PERIRENAL SCLEROSIS**—Following injury if there are both hematoma and infection large amounts of scar tissue may be deposited about the kidney causing severe late pain and sometimes a palpable mass

**DIVERTICULUM OF THE URETER**—This condition is rare and usually follows injury Large or small cavities develop which are filled with urine and communicate by a small opening with the ureter The cavity may grow very large and acquire a fibrous wall

**Symptoms**—The three cardinal symptoms of renal neoplasm are hematuria mass and pain Yet it is true that pain is often



a late symptom and that by the time a palpable mass develops it is in most cases too late for successful treatment. Hematuria therefore particularly if without pain frequency of urination or any other symptom is the most important danger signal and its source should always be determined by thorough examination at the earliest possible moment. The examination should not be delayed if the bleeding stops as weeks or months may elapse before blood again ap-

pears. Hematuria is unusual occurring in 10 per cent or less of the cases.

Renal cysts usually cause no symptoms except a mass in the region of the kidney occasionally there is pain.

Tumors of the ureter usually cause hematuria. Obstruction is common giving rise to renal colic and hydronephrotic enlargement of the kidney.

Hematuria is a common symptom of polycystic kidney. The kidneys can usually be



Fig 659



Fig 660

Fig 659—Roentgenogram of man aged thirty five hematuria and pain in left kidney diagnosis of renal neoplasm possibly papilloma of the pelvis so the entire ureter was removed with the kidney diagnosis confirmed preoperatively radiation on patient as all three years after operation.

Fig 660—Roentgenogram of a man aged sixty-one hematuria and mass in right side diagnosis of cortical renal neoplasm nephrectomy was performed the neoplasm proved to be a clear cell adenocarcinoma (hypernephroma) patient was well one year after operation.

pears. Unfortunately there are a good many cases in which no symptom appears until the growth is far advanced.

Pressure on the spermatic veins by the tumor may cause hemilateral varicocele in the male. Edema of the legs and ascites may occur.

In the embryonal neoplasms of children an abdominal mass is usually the first symptom and pain does not ordinarily begin until

felt. In the later stages pain is common and finally the symptoms of uremia appear.

**Diagnosis—General.**—The diagnostic study includes seven steps some of which may be omitted in some cases: (1) history (2) physical examination (3) examination of the urine (4) intravenous urography (5) ureteral meatoscopy (6) functional study of the two kidneys and (7) retrograde pyeloureterography. The first four of these

can be undertaken by any physician and will very frequently establish the diagnosis.

The history should particularly include the duration and the character of hematuria and of pain if present and also the number of attacks of each.

A careful physical examination must be made to disclose palpable renal tumor and secondary effects such as ascites, edema, varicocele and dilated veins and also to detect metastases especially in the cervical glands. If the function of one kidney is destroyed by a tumor the other will also be enlarged as the result of compensatory hypertrophy.

The urine is examined for microscopic blood. If pus is present stone or tuberculosis is suspected if these are ruled out neoplasm is more likely. Sometimes tumor cells or fragments may be identified. Casts and much albumin make one think of the possibility of acute or subacute nephritis as the cause of blood in the urine.

**Intravenous Urogram**—A plain film should be taken first to exclude stone. Intravenous urography is useless for the early diagnosis of renal tumor as both false positive and false negative findings are frequent. If a kidney is functionless there will be no shadow whatever.

If a renal neoplasm is seriously suspected cystoscopic examination should be carried out. If hematuria is present inspection of the ureteral orifices (mentoscopy) will show from which side the blood is coming.

Ureteral catheters are then passed to both kidneys and urine is collected. If the urine is bloody from both kidneys the condition is probably a nephritis. A comparative functional test preferably with phenolsulfonphthalein will show how much the function of the affected kidney is damaged and also whether the other kidney has assumed its extra work properly.

A retrograde pyelogram is then taken enough 12 to 18 per cent solution of sodium or iopax being injected to fill the pelvis. The catheter is partially withdrawn to allow the ureter to fill. Stereoscopic films are best.

The characteristic picture is due to a tumor mass which projects into the pelvis and one looks therefore for a rounded filling defect with the convexity toward the hilum since the tumor springs from the paren-

chyma. Sometimes the pelvis is almost or entirely obliterated by a large tumor or by blood clots in the pelvis. The projecting mass may obliterate one or more minor calices. The kidney may be pushed out of its normal position by the tumor. A tumor in the lower pole may increase the distance between the ureter and the lowermost portion of the pelvis. Renal cysts may obliterate part of the pelvis and displace the kidney but they never cause the typical rounded filling defects of a tumor. Teratoma, sarcoma and epithelioma deform the pelvis sometimes extensively but according to no rule and are therefore very difficult to diagnose. Polycystic kidney has an elongated pelvis with elongated spider-like calices and often numerous round filling defects due to the cysts. It always involves both kidneys sometimes one being much more deformed than the other. Ureteral neoplasms may cause filling defects in the ureter which are often very difficult to bring out satisfactorily. Study of the renal outline may show irregularity due to tumor.

These same steps should be taken in children as cystoscopic examination is now possible in the youngest infants. While embryomas give no characteristic pyelogram marked distortion proves the renal origin of the tumor and in addition the other kidney can be properly studied.

The pyelogram will establish the diagnosis in most cases or at least in from 70 to 75 per cent. If the diagnosis is not certain and particularly if an enlarged kidney can be felt it is better to explore as time is a tremendously important factor. Weeks, months or even years may be wasted waiting for a positive pyelogram.

If the aforementioned plan is followed the differential diagnosis seldom presents difficulties. Carbuncle of the kidney and perinephric abscess may simulate a tumor of the kidney but are characterized by fever and leukocytosis. Hydronephrosis is apparent, but it must be remembered that it may accompany a tumor.

If a neoplasm is suspected any nodules in the skin or large glands should be studied by biopsy and a roentgenogram of the chest should be made. If any pulmonary metastases are found nothing can be done except administer palliative treatment.

**Treatment**—There is only one treatment for renal neoplasm nephrectomy performed as early as possible. Unless removal of the tumor is complete there is no hope of cure. Before operating one must make sure that the other kidney is healthy and able to maintain life. The approach is usually extraperitoneal and lumbar but the transperitoneal route may be preferable for a very large tumor. An effort should be made to ligate the pedicle before disturbing the tumor. If a lumbar incision is used it is extended straight across the abdomen to the edge of the rectus muscle giving access to the pedicle. Resection of the twelfth rib is advisable in large tumors. In transperitoneal operations the pedicle should be sought first. The ureter is crushed ligated and divided with the cautery. The kidney should be opened as soon as it has been removed and if a papilloma of the pelvis is found complete ureterectomy including a button of bladder wall must follow to eradicate any possible implants in the ureter.

Intensive roentgen therapy has produced no cure in tumor of the kidney but is often very useful in reducing the size of a tumor preliminary to operation. Tumors so large as to be inoperable should always be irradiated as they may be reduced sufficiently to become operable. These tumors are not suitable for radium treatment.

Embryomas must be removed if possible but may recur locally. Ladd has an excellent series of long term cures (23 per cent) after early and very radical surgical removal (transperitoneal). Postoperative irradiation is of doubtful value.

Renal cysts are treated by removal of that portion of the kidney which bears the cyst unless more than a third of the kidney is involved. In that case nephrectomy is performed.

There is no treatment for polycystic kidney unless complicated by stone hydro-nephrosis or infection in which case the usual treatment for these conditions is given. Hemorrhage may be arrested by pelvic lavage with silver nitrate or epinephrine. Operative puncture of the cysts (Rovsing's operation) has given unsatisfactory results.

Aneurysm of the renal artery is treated by nephrectomy with ligation of the artery proximal to the aneurysm.

Tumors of the ureter are treated by complete nephroureterectomy.

In cases of inoperable tumor pain and hemorrhage must be combated. Pain is often due to bleeding with clots. Pelvic lavage with silver nitrate or epinephrine may stop the bleeding. Transfusion is useful. If all else fails ligation of the ureter is usually successful.

**Prognosis**—Any kind of renal neoplasm is almost invariably fatal if not treated. In about one third of all cases in which the patient applies for treatment the tumor is inoperable. Of the cases which are considered operable there will be some in which complete removal of the tumor is not possible. These patients will die. If removal is apparently complete and if metastases do not develop there may be recurrence at any time up to ten or twelve years later. The number of permanent cures is distressingly low not over 10 or 15 per cent. In the others metastases will finally become evident but they were undoubtedly present but not demonstrable before operation. The operative mortality varies in different series from 4 to 33 per cent. Generally speaking the results are better when operation is performed soon after the appearance of symptoms but there are rather numerous exceptions to this rule.

The results of benign papilloma of the pelvis are much better than this if the ureter is completely removed. In most of these cases a cure is obtained.

Embryomas in children are very fatal but recurrences are rare after two years. Ladd's work offers great hope for improvement in results after operation.

Sarcoma and epithelioma are practically always fatal.

An angioma is harmless unless it ruptures into the pelvis causing hemorrhage. Nephrectomy is curative and operative death rarely occurs.

In simple cyst of the kidney there is no mortality except the operative which depends largely on the skill of the surgeon.

Patients with polycystic kidneys practically never live to be more than fifty years old. Very little can be done to prolong life except by treating intercurrent disease due to stone infection obstruction etc.

Tumors of the ureter are difficult to diag-

nose and therefore are more apt to be treated unsuccessfully than tumors of the kidney. No accurate figures as to results are available.

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## TUMORS OF THE BLADDER

**Historical.**—In the early part of the last century the cystoscope was being developed in Berlin and Vienna. Prior to this tumors of the bladder had been recognized both at autopsy and at operation. The peculiarities of papilloma of the bladder were known, i. e., (1) they do not invade the bladder; they do not metastasize; they are multiple and they tend to recur after surgical removal. Nitze in Berlin was the first to recognize and treat them seriously through the cystoscope. He used a wire loop heated electrically, red hot, snared the tumors with this, burned them off and had the patient pass the burned off portions on urination. He published in 1876 a report of a large series of cases of papillomas so treated. Because of the large size of the instrument and the difficulty of the procedure, no other surgeon to my knowledge ever used it extensively. Even with this noteworthy achievement by Nitze, surgeons were everywhere very reluctant to accept his teachings. Not until Beer in New York in 1910 used a simpler device of high frequency current to destroy papillomas did the method come into its own. All urologists used it both for papilloma and for carcinoma in the former with excellent results and in the latter disastrously. Because of its impotence in carcinoma, surgical excision of these tumors was developed. Beer, Geraghty, Young, Squires, the Maros, Lower, Albarran and others began to use it. But the removal of these tumors is difficult surgically because most of them arise in the base of the bladder near

the ureters, hence at first the surgical results were not brilliant. Because of this the author started the radium treatment of these tumors in 1915. Various forms of radium application were used but the most trustworthy were the ones developed by the author of both cystoscopic and suprapubic implantation of radium seeds. The first suprapubic implantation was done in 1920 at the Memorial Hospital in New York. The caustic glass seeds were originally used and finally gold seeds which filter out the caustic beta rays. Urologists were slow to take up this method because of the difficulty of getting radium in proper form. Young, Geraghty, Kelly and Burnam developed other forms of radium technique particularly the endovesical application. Finally deep x-ray therapy was extensively tried out and likewise surgical diathermy.

**Etiology.**—Little is known of the cause of tumors of the bladder but it is recognized that the workers in aniline dye factories are subject to them. They may arise years after the workers leave the factory. Yet the urine of these workers does not differ at all chemically or otherwise from the urine of persons outside the dye factories.

Most of the tumors start in the base of the bladder around the trigone. This is the region which is most often the site of cystitis caused by infected urine from the kidneys or infection by way of the urethra (gonorrhea). This suggests that infection and irritation may be a factor in the cause of vesical tumors but certainly it is only one of several factors.

**Pathology.**—Tumors of the bladder are classified as follows:

### Primary tumors

#### A From epithelial tissue

- 1 Papilloma
- 2 Papillary carcinoma
- 3 Infiltrating (non papillary) carcinoma
  - a Simple carcinomatous ulcer
  - b Flat squamous cell carcinoma
- 4 Adenocarcinoma

Generally secondary to a tumor of the prostate but very rarely primary and if so originating in Brun's glands.

- 5 Colloid carcinoma
- From Brun's glands (rare)

#### B From connective tissue

- 1 Fibroma
- 2 Myxoma
- 3 Sarcoma

#### C From muscle tissue

- Myoma

#### D Heterotopic forms

- 1 Chondroma
- 2 Rhabdomyoma
- 3 Dermoid

#### F Cysts

Tumors secondary to tumors in the following locations\*

- A Prostate
  - 1 Fibrocarcinoma
  - 2 Adenocarcinoma
  - 3 Adenoma
  - 4 Fibroadenoma
  - 5 Sarcoma (young adults)
- B Seminal vesicles
  - Carcinoma
- C Intestinal tract
  - Glandular carcinoma
  - Adenocarcinoma
  - Mucous carcinoma
- D Cervix
  - Squamous carcinoma
  - Adenocarcinoma (rarely)
- E Vagina
  - Sarcoma (especially in children)

The first three types of tumors (papilloma, papillary carcinoma and infiltrating carcinoma) which arise from the epithelial lining of the bladder are by far the most important and will be considered in some detail.

As far as the secondary tumors of the bladder are concerned it is well to remember that tumors arising in organs adjacent to the bladder may grow from these organs into the bladder. Such tumors are of the same pathologic type as the primary tumor and can often be identified by this alone. This is particularly true of vesical tumors secondary to tumors of the prostate (adenocarcinoma) and intestines (glandular carcinoma).

The two most important sources of secondary vesical tumors are the prostate and the cervix.

**Papilloma, Papillary Carcinoma and Infiltrating Carcinoma**—From the clinician's standpoint and it is the clinician who is responsible for the diagnosis and treatment these three types of tumors must be identified grossly with reasonable accuracy. If microscopic examination of the entire tumor is possible and if the findings disagree with the clinical estimate then the clinical diagnosis must give way to the pathologic diagnosis. If however as is often the case only small portions of the tumor are available for the pathologic diagnosis then more weight is placed on the clinical picture. In other words vesical tumors sometimes vary in their structure and the pathologic examination of the top of a tumor may not reveal the real structure of the base.

A *papilloma* may be single or multiple and may arise from any portion of the interior of the bladder. As seen through the cystoscope it resembles delicate pink seaweed waving in the vesical fluid. Many pink tufts may spring from the pedicle which attaches it to the bladder. It is very rarely white or sloughy unless covered with phosphate deposited from the urine. If the tumor is white or sloughy the tumor is in all probability cancerous. Microscopically the pedicle is composed of connective tissue, unstriped muscle fibers, blood vessels, nerves and surface epithelium. The latter is continuous with the epithelium of the mucosa. In the villous portion of the tumor the epithelial elements as well as the connective tissue fibers combine to form the bulk of the growth.

The tendency for a papilloma to recur after its removal is a well established fact. The growth frequently reappears as a simple benign tumor though in some instances it may be distinctly malignant in character. At times several apparently benign papillomas may be found one of which may prove to be malignant. This fact however may not be known until a microscopic examination is made for the two forms closely resemble each other macroscopically. A tumor may show in one part the characteristics of a pure papilloma and in another part those of a carcinoma.

The cystoscopic picture of *papilloma* and *papillary carcinoma* may be identical hence the true diagnosis must rest on the pathologic examination. As a rule a papillary carcinoma is single, may be partly or entirely sloughy and generally looks firmer and harder than a papilloma. Mandelbaum says:

Histologically the picture of carcinoma in well advanced cases is typical. In earlier stages the epithelial cells lose the typical arrangement as seen in papilloma and are polymorphous in character; the nuclei become larger and more irregular; an atypical proliferation occurs and finally the infiltration of the stroma takes place. Proliferation of the bladder wall is very rare and metastases occur only in the late stages. The tumor in its later stages may infiltrate the wall of the bladder.

An *infiltrating carcinoma* is entirely different from either of the other tumors al-

though the papillary tumor may become infiltrating. It usually begins as a flat ulcer which is difficult to differentiate except by means of the microscope from a simple or tuberculous ulcer. It is generally single and

the work of Broders an attempt is made by pathologists to grade all tumors in relation to their malignancy. Four grades were chosen by Broders grade 1 being the least malignant and grade 4 the most. This scheme has

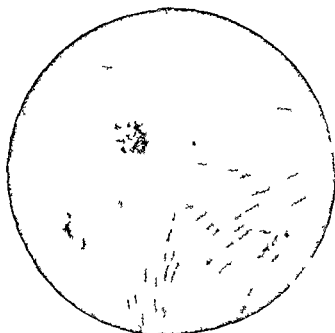


Fig. 661—Papilloma of the bladder (Model made from life by G. R. Richardson)



Fig. 662—Papillary carcinoma of the bladder (A model made from life by G. R. Richardson)

sloughy. Its edges become thickened and raised and it rapidly infiltrates the vesical wall. It is the most malignant of all tumors of the bladder.

**Grading of Tumors**—In accordance with

proved to be valuable in the diagnosis of tumors of the bladder. In the bladder grade 1 has represented pure papilloma and grades 2, 3 and 4 have represented carcinoma. This gradation has been objected to by Wing

because he does not consider papillomas to be in the class with carcinoma. His gradation is papilloma and grades 1, 2 and 3 of carcinoma. If we accept the grade 4 classification, more tumors of the bladder are in grade 2 and the fewest in grade 4. There exists still another class of tumors of the bladder, called by Geraghty malignant papilloma and by pathologists papilloma with atypical cells, which we believe should be classified as grade 2 carcinoma. In finally classifying tumors of the bladder it is probable that the three original classes, viz., papilloma, papillary carcinoma and infiltrating carcinoma, are the most satisfactory

pathologist change later to a highly malignant, rapidly growing, infiltrating carcinoma.

Another phase of the question is the varying diagnoses of the pathologist of different specimens taken from the same patient. For example, in 19 of 46 cases at the Memorial Hospital there were pathologic variations in the diagnosis of different specimens. It is always wise to take several specimens in these cases if the growth is believed to be malignant yet pathologically the report is papilloma.

*Incidence*—Papilloma of the bladder may occur at any age between two and one-half and seventy-nine years. As a rule it occurs



Fig. 663—*a*, Simple papilloma of the bladder, low power, *b*, infiltrating squamous cell carcinoma of the bladder, low power. Both of these illustrations are from the Bladder Carcinoma Registry, Army Institute of Pathology, Washington, D. C., courtesy of Dr. Russell Ferguson.

The grades of malignancy may be used to modify the diagnosis in these three classes. The grading is of more value to the urologist who surgically removes the tumors than to the urologist who uses radium therapy. The grade 4 tumors constitute the worst operative risk.

#### *Changes of the Grade of Malignancy—*

Some tumors of the bladder change their grade of malignancy, this, in our experience, being due to the trauma of imperfect operations or to operative devices such as fulguration and the like. We have seen a tumor which filled the entire bladder and was diagnosed as papilloma by a competent

at an earlier age than carcinoma. On the other hand, the age periods of the greatest frequency of these two overlap, that of papilloma being between forty and sixty, and that of carcinoma between fifty and seventy. Geraghty gives the age in 73 cases of papilloma as follows:

Age, in Years	Cases
10 to 20	1
21 to 30	5
31 to 40	13
41 to 50	23
51 to 60	18
61 to 70	11
71 to 80	2

In the writer's series of 127 cases of carcinoma of the bladder the incidence was as follows

Age in Years	Cases
20 to 30	3
30 to 40	16
40 to 50	20
50 to 60	37
60 to 70	37
70 to 80	14

Of 144,774 cancer deaths in the United States during 1937, 4611 were due to cancer of the bladder. This 3.2 per cent incidence is about half that of cancer of the prostate and one fourth that of cancer of the breast. According to the Division of Vital Statistics of the Bureau of the Census figures there are from 15,000 to 20,000 cases of cancer of the bladder.

**Sex.**—In 153 cases of carcinoma of the bladder 119 were in males and 34 in females. This same ratio holds for papilloma.

**Symptomatology.**—The reason the diagnosis and treatment in a large majority of cases of tumor of the bladder are delayed from one to two years after the appearance of the first symptoms is that the physician himself does not consider seriously the one single symptom of hematuria.

**Duration of Symptoms.**—As will be seen from the following table the large majority of patients show the symptoms for over a year before the condition is diagnosed. In 101 cases (116 advanced and 5 early carcinoma) the following duration of symptoms was found:

Duration of Symptoms in Months	Cases
1 to 3	13
3 to 6	14
6 to 12	37
12 to 18	3
18 to 24	16
24	32

If the tumors in these cases had been diagnosed within three months of the appearance of the initial symptoms the percentage of cures could have been at least doubled.

**First and Second Symptoms.**—Hematuria and disturbances of urination are the two symptoms of greatest importance. While hematuria may be a symptom of many con-

ditions other than that of tumor of the bladder the fact that in 130 of 138 cases it was one of the symptoms shows the importance of recognizing this fact. Every patient presenting the symptom of hematuria should have a careful urologic examination. The symptoms of the disturbances of urination are not so important because anything that changes the contour, the capacity or the irritability of the bladder, the reservoir of the urine causes some changes in what is known as normal urination. One fact that should be kept in mind in making a differential diagnosis is the fact that tumors of the bladder rarely cause urinary retention while tumors of the prostate frequently do.

**Renal Symptoms.**—Because of ascending infection from the bladder (and many vesical tumors are infected) or because of some obstruction of the ureteral orifice about a third of all the patients with tumors of the bladder have considerable disturbance of the kidneys. This should always be kept in mind when the cure of a vesical tumor is undertaken because in most fatal cases the patient dies because of severe infection of the kidneys the function of which has been impaired.

**Course.**—Tumors of the papillary type may remain confined to the bladder for years. This is particularly true of pure papillomas and less so of papillary carcinomas. Spontaneous cure is unknown. Advanced tumors grow beyond the bladder generally to the retroperitoneal lymph nodes of the pelvis. They may invade the bones of the lumbar spine and pelvis and may invade the liver or the lungs. The osseous involvement is readily shown by roentgenograms and is generally of the osteoplastic type and therefore different from that of a prostatic carcinoma which is of the osteoclastic type.

**Cystoscopic Examination.**—Cystoscopy is carried out with two ideas in mind: first to obtain a general picture of the tumor and second to obtain a small specimen for pathologic examination. The specimens obtained by the cystoscopic forceps are very small indeed but as a rule quite sufficient for the diagnosis.

A rectal examination should never be omitted because an invasion of the base of the bladder may be distinctly felt in this way. Bimanual palpation should also be in



cluded as a tumor may thereby be felt extending suprapubically

**Cystogram**—The air cystogram has in late years assumed considerable importance in determining not the kind of tumor but the extent of the tumor. The procedure is quite simple. The catheter is introduced into the bladder, the fluid is withdrawn and air is pumped into the bladder gently and to the point of pain, then a roentgenogram is quickly taken.

**Differential Diagnosis**—The order of importance of conditions in the bladder which may be confused with carcinoma are: (1) blood clot (2) simple ulcer (3) ulcer with calcareous encrustations (4) stone (5) tuberculous inflammation (6) leukoplakia (7) cystitis cystica (8) cysts of the prostate and (9) hypertrophied lobes of the prostate.

**Treatment**—In 177 out of 298 patients seen by the author at the Memorial Hospital, the location of the tumor was near the urethra or near one or both ureters. The sizes of the base of the cancer in 298 cases were as follows: 40 were less than 5 sq cm, 56 were between 5 and 10 sq cm, 39 were between 10 and 20 sq cm, and 86 were larger than 20 sq cm. In 7 cases the size was not estimated. This shows that 17 per cent of the cancers had bases between 10 and 20 sq cm, and 39 per cent had bases of more than 20 sq cm.

These two conditions must be kept in mind when any treatment is considered. It must be realized that most vesical tumors are located in the base of the bladder and that most of them are extensive when first seen.

**Treatment of Papilloma**—If the diagnosis has been assured by the microscopic examination of a piece of the tumor, the tumor should be burned off with some form of electric spark, this treatment being called fulguration. This as a rule can be accomplished through the cystoscope. If the growth is too extensive, however, it will be necessary to make a suprapubic opening. It should be recognized that these tumors recur and that the patient must be watched cystoscopically for years. Extensive papillomatosis should be treated by total cystectomy and skin implantation of the ureters.

**Papillary Carcinoma and Infiltrating Car-**

**cinoma**—There are two schools at the present time, each of which believes that its method of treatment is the proper one for tumor of the bladder. The first believes in the complete operative removal of the tumor with the removal of any part of the ureter that is involved and the disposal of the remaining portion of the ureter by different methods. Beer was the outstanding representative of this school. Since in most cases the tumor involves the base of the bladder, the operation is difficult and fraught with considerable danger, and the removal of part of the ureter may mean the destruction of the kidney, which it drains. No matter what disposal is made of the ureter. The second school is represented by those who believe that radium presents the most adequate means of treating these tumors. This school of which the author is one believes that radium treatment of cancer of the bladder often can be accomplished successfully by means of the cystoscope with out any operation. If operation is undertaken and it is desirable to open up the bladder and implant radium in that way, the operative mortality of such an operation is considerably lower than if an attempt is made to cut out the tumor. Radium implantation as perfected is a comparatively simple procedure as compared with that of operative removal, and the chance of destruction of one or the other kidney is considerably less. It is believed that in a large number of inoperable cases the condition can be controlled by radium therapy.

**Summary of Five Year Results of Radium Treatment**—Of 957 personal cases, unchecked and consecutive of bladder cancers seen up to and including the year 1937, 312 were papillary cancers and 143 infiltrating cancers. Of the 119 papillary tumors, 3 were operated on palliatively and 1 of the 143 infiltrating tumors, 10 were either not operated on at all or operated on for palliation. These 15 cases are excluded from the statistics because some of them had metastases on some of the bladder was merely felt through the suprapubic opening and in some a reason was implanted because of hematuria. This leaves 109 papillary tumors and 133 infiltrating tumors. Of the 109 patients with papillary tumors, the tumors of 20 were proved cured, but the patients died of some intercurrent disease or were lost track of before the end of the five year period. The same was true of 10 of the 133 patients with infiltrating tumors. This leaves the following percentage of five year cures: Of 89 patients with papillary cancer, there were 50 or 56.1 per cent, who were well for five years. Of 121 patients with infiltrating cancer, there were

35, or 23.9 per cent, who were well for five years. Of 210 patients with combined papillary and infiltrating cancer, 83, or 40.1 per cent, were well for five years.

The pathologic diagnosis in all these cases has been made by examining pieces of the tumor obtained either cystoscopically or at the suprapubic exposure. It is never possible to obtain the entire tumor with its base for examination. Because of this the diagnosis has been modified by the clinical observations. If a tumor is reported as papillary cancer and if at operation the base of the tumor is found to be indurated that tumor is classed as infiltrating rather than papillary cancer. Such induration is gauged both by the actual feel and by the sense of resistance felt by the needle bearing radon seeds. These two methods are extremely accurate in determining induration and therefore classifying the tumor as infiltrating. In 17 cases there was no pathologic diagnosis or a diagnosis of papilloma. But 9 of these 17 are reported as five year cures. Thirteen patients died of cancer and 1 was lost track of. This indicates that the clinical diagnosis in these 17 cases was accurate. In our series "papillomas with atypical cells" were classed as papillary carcinoma. The malignancy in this class of cases has been doubted by some pathologists and urologists. There is no question that a small percentage of these tumors have been easily cured by various methods such as fulguration, excision and roentgen rays and do not act like malignant tumors. By far the larger percentage, however, have all the attributes of real malignancy. They react badly or not at all to fulguration and they tend stubbornly to recur. There is no pathologic or clinical means whereby one may distinguish between these two groups and until there is it is only fair and safe to group them under one class, papillary cancer.

Radium alone in different forms has been used to control these tumors. Suprapubic implantation was done 183 times and cystoscopic implantation 89 times in the 937 cases. These figures indicate that in 85 cases a combination of suprapubic and cystoscopic implantation was done to control the tumor.

If the tumor in question was reasonably small and situated in a part of the bladder which could be reached adequately through the cystoscopic treatment through the cystoscope was relied upon. This was done whether the tumor was papillary or infiltrating. We have lately successfully extended the scope of this method to larger tumors. It is the method of choice and if it can be accomplished saves time in the hospital, diminishes the hazards of operation and minimizes bladder and kidney infection. It takes persistent, repeated and intelligent cystoscopic treatment. When the suprapubic method is used the operation is simply a means to the end of implanting radon seeds into the tumor under direct vision. It is significant that in a fair percentage of cases both cystoscopic and suprapubic methods have been necessary to control the disease.<sup>2</sup>

**Multiplicity of Tumors.**—The Carcinoma Registry has emphasized that vesical cancer is more often multiple than single. The registry has even seen fit to change the pathologic diagnosis from papilloma to carcinoma on the clinical basis that carcinoma is multiple. From the clinical standpoint the fact that there are several tumors instead of one indicates in a broader

sense that multiple tumors constitute a malignant element as compared to a solitary tumor. On the other hand, from our records carcinoma of the bladder is usually single. In the cases in which control was obtained the carcinoma was single in 73 and multiple in 23 cases, in the cases in which control was not obtained, the carcinoma was single in 85 and multiple in 31.

**Factors Influencing the Type of Therapy.**—1 **Size of tumor.** Small tumors papillary or infiltrating, are best treated cystoscopically with implantation of radon seeds or radon applications. Large tumors if papillary, are treated by means of suprapubic radon implants. Large tumors if infiltrating are treated according to the methods to be outlined presently.

2 **Grade of tumor.** Malignant growths of lower grades are treated as just outlined. Growths of higher grades particularly grade 4 are treated by external irradiation and cystoscopically.

3 **Position of the tumor.** When the tumor is on the base of the bladder (75 per cent of all tumors of the bladder) and encroaches on the ureters or the internal urethra irradiation is superior to operative removal. If cystotomy is necessary because of the size or site of the tumor, ureteral catheters should be passed up the dilated ureters brought out of the suprapubic wound and left in place several days to insure proper drainage of the kidneys. If this is impossible there is a period of watchful waiting after the radon implantation. If one kidney becomes infected and causes sepsis which cannot be controlled then nephrectomy is the operation of choice, provided the remaining kidney is normal.

4 **Condition of the kidneys.** If the kidneys are infected and the ureters and renal pelves are dilated, cystoscopic treatment with radium is superior to open operation. The suprapubic operation and the massive implantation of radon seeds only extend the infection. The implantation or application of radium cystoscopically can be carried out in divided treatments.

Tumors of the bladder vault and extensive papillomatous should be operated upon the former by partial resection removing all fatty tissue overlying the bladder vault and the latter by cystectomy with skin implantation of the ureters.

**Comparison Between the Results of Surgical and of Radiation Treatment.**—Probably the best surgical results after five years show control in 25 per cent of cases. These results are computed on the basis of the total number of cases in which the tumor could be removed surgically. Obviously there are a large number of cases in which surgical intervention is impossible and the statistics do not include these. Our statistics include all cases in which the cancer was believed to be confined to the bladder. The size of the growth has not prevented an attempt to obtain a cure. The results of irradiation obviously must be better than the results of surgical treatment since we can report cures in 40.1 per cent of the cases in which treatment was given.

**Disadvantage of Radium Treatment.**—Implantation of seeds into an infected tumor increases the severity of the infection. A slough is always formed and presents a focus of increased infection. This slough may become incrustated with calcareous deposits and stone

formation may result Asepsis and a certain amount of antiseptics help obviate this condition Cleansing the bladder with antiseptic washes before and after cystoscopic implantation extreme care in the suprapubic approach and painting the tumor with a mild solution of iodine before the radium is implanted all help

Vesicovaginal fistula may occur either as a result of radon implantation or of the depth of the tumor or both There were 3 such cases in our series One patient died and 1 lived for five years dying of an acute renal infection One patient has lived for about two years and is reasonably comfortable after skin implantation of the dilated ureter of the single kidney

*Suprapubic versus Cystoscopic Radiation*—Not only the size of the tumor but the infection of the tumor and the condition of the kidneys should determine the method of treatment My colleagues and I are steadily leaning more and more toward cystoscopic treatment If the tumor is ulcerated and infected and if one or both kidneys are hydronephrotic suprapubic implantation of a large amount of radon is a dangerous procedure from the standpoint of the infection

*Forms of Radiation Treatment*—1 Radon Seeds These have constituted the best method for both suprapubic and cystoscopic applications of radium

2 X ray Al no Much has been written of late about control by means of x ray treatment alone of cancer of the bladder Notwithstanding repeated and persistent attempts to control the more difficult types of vesical cancer deep x ray therapy in our hands has signally failed The reports of cases in which this treatment has been given have been singularly inadequate as to pathologic data and time of cure and there was failure in at least one such report to mention the essential fact that radium was used as an adjunct to the x ray treatment The use of x ray in the milder forms of cancer or papilloma of the bladder which could easily be controlled by cystoscopic fulguration or application of radium seems unjustifiable I have seen extremely severe effects after prolonged x ray treatment and I have known of 9 patients who died of skin destruction after such irradiation In 1 of these cases an infiltrating tumor had been controlled and the bladder was free from tumor In the other case there was marked regression of the tumor Most cancers of the bladder are radiosensitive The present knowledge of how to give deep x ray therapy alone is sufficient to make cure possible in but very few cases This type of treatment may well be used as an adjunct to operation or radium treatment in cases of higher grades of malignancy particularly grade 4

3 X ray Plus Radon Seeds I have attempted in 3 cases of extensive infiltrating ulcerated carcinoma to combine the first two types of treatment mentioned Radium is applied either cystoscopically or suprapubically Death has occurred in all 3 cases

4 Fulguration and Surgical Diathermy The only statistics recording five year cures of carcinoma of the bladder by surgical diathermy are those published by Counsellor and Brunsch from the Mayo Clinic They reported the end results in 17 cases of inoperable and non-resectable cancer They have an outstanding 88 per cent of five year cures This has never been duplicated by any other clinic

Many so-called loose reports have been made about

the removal of tumors of the bladder by means of the instrument used for transurethral resection of the prostate but no end results have as yet been reported The author cannot condemn too strongly the inadequacy of this last method

5 Fulguration and X ray Therapy Considerable work has been earned on lately with the instrument used for transurethral prostatectomy Extensive tumors of the bladder have been treated with fulguration followed by x ray therapy No extensive series as far as I know has been reported on It does not seem as though fulguration would work as an adjunct to x ray as does radium

6 Preoperative or Postoperative X ray Treatment Theoretically it seems that either of these procedures might so partially devitalize tumor cells that the operative removal would result in a larger number of cures I believe however that this is more a theoretical than a practical consideration At any rate I have not seen any reports of series of cases to substantiate the claim

7 Application of Radium The application of a large amount of radium gram 1 (unscreened) to a tumor for an hour at a time by means of the cystoscope and so under direct observation seems to offer a chance for the control of large ulcerating cancer of the bladder These growths are virtually beyond ones grasp at present This type of treatment is supplemented with deep x ray therapy I have seen several patients in whom this method has been effective With this type of therapy the infection in the tumor is not made worse, as is the case when radon seeds are implanted The suprapubic operation is omitted Only further work can determine however whether it will be possible to extend the number of cases in which control of cancer of the bladder is achieved by this method

*Total Cystectomy and the Treatment of Tumors of the Bladder*—Beer, Quimby, Smith, Hinman, Lower and others have believed that total cystectomy should be done in "a group of cases in which the trigone is so extensively involved that the ureters cannot be spared and both ureters have to be sacrificed In addition many of these cases have extensive involvement of the neck so that the infiltrating growth involves half or more of the sphincter area and has invaded underlying tissues particularly the adjacent prostatic tissues in the male In this group of extensive infiltrating growths situated at or in the neck of the bladder involving frequently the ureter orifices the problem is most serious What should we do? What can we offer these patients?"

With the improvement of surgical technique the mortality of this operation has been in the past fifteen years markedly reduced until at present it is between 15 and 20 per cent The mortality is considerably higher if the ureters are implanted in the intestines than if they are implanted in the skin I believe the latter method is certainly the operation of choice We must always remember however that the operation is severe and that even if successful there is no absolute assurance that the cancer has been eradicated I believe it should be used only as a last resort when appropriate methods of irradiation have been tried and have failed

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## CHRONIC PROSTATITIS AND SEMINAL VESICULITIS

The medical profession including those in all its special branches have become more alert in looking for focal infections in the prostate and seminal vesicles as the source of many unexplained conditions noted in their respective fields.

**Etiology.**—Since the advent of the sulfonamides and penicillin a complete revision of statistics on gonorrhea as an etiologic factor in prostatitis and seminal vesiculitis has become necessary. Invasion of the gonococcus into the prostate and seminal vesicles in cases treated early by these agents is at most unknown. Some sulfa resistant and some untreated patients may suffer from this complication but most prostatic infections are mixed in character and are blood borne. It is conservative to estimate that 20 to 30 per cent of all men past 40 years of age will show pus cells in the prostatic secretion. Pathologists report chronic inflammation in 90 per cent of prostatic tissue removed for other causes.

**Pathology.**—Chronic prostatitis in mild cases shows inflammation of the epithelial lining of the acini and ducts leukocytes

coming up from the basement membrane and pouring out on the surface of the epithelium. If the ducts are not occluded by this debris the pus will drain into the posterior urethra. In the more severe types considerable edema may occur which blocks the prostatic ducts and results in subsequent distention. Not infrequently small abscesses may develop. When this occurs the layers of connective tissue become involved and the abscesses may rupture into the urethra. In the late stage of such an infection the entire prostate gland may become hard fibrous and contracted. These small abscesses may coalesce into one large abscess which may rupture into the urethra. Such an occurrence may lead to a persistent cavity which continues to drain into the posterior urethra. Abscess formation following infection of the seminal vesicles is rare. When the infection spreads beyond the prostate or seminal vesicles a paravesical infection results which may complicate recovery.

**Examination of the Prostate and Seminal Vesicles.**—It is best to begin the examination by having the patient pass urine into two glasses. If the voided urine shows shreds or contains pus cells urethral and vesical infection (cystitis) must be considered as a possible cause of the symptoms. The anterior portion of the urethra is then thoroughly flushed with sterile saline solution or water. The patient should stand with the feet apart and with the body flexed on the thighs at a right angle and should rest his elbows on a table or chair. With the index finger in the rectum the surgeon palpates the posterior surface of the prostate in order to determine the size, shape and consistency and the presence or absence of nodules and induration. After this examination is completed the finger is then passed upward to the seminal vesicles; these cannot be palpated in all cases. Usually in prostatitis of the parenchymatous type the gland is enlarged slightly, tender to touch and asymmetrical in outline. The gland is massaged by a gentle stroking beginning at the lateral border and by applying firm continued pressure as the finger is moved toward the medial sulcus of the gland. The finger is then passed beyond the highest portion of the prostate and by moderate pressure is brought downward along the prostatic ure-

thra Force or haste in massaging the prostate may result in failure to obtain any secretion

A sterile watch crystal or slide is held with the free hand under the meatus to catch all drops of the expressed secretion for microscopic examination in liquid state under  $1_6$  power lens

The secretion from a normal prostate may contain from 1 to 5 white blood cells per field in infected prostate may show from 10 to innumerable white blood cells per field Some urologists feel that the presence of clumps of pus cells indicates a severe or a more chronic infection Secretion from a chronically infected prostate will appear free from bacteria by simple staining in 30 per cent or more of cases but cultures will be positive in 70 per cent of these cases according to Young Despite all attempts to obtain a clean secretion contamination of the prostatic fluid occurs in a large number of cases *Staphylococcus albus* and colon bacillus are by far the most frequent organisms found *Streptococcus* is found in 5 per cent *Bacillus pyocyaneus* in 1 per cent and the gonococcus rarely

It is impracticable in most cases to separate the prostatic secretion from the vesicular secretion This may be attempted however by massaging the vesicles and securing the contents in separate containers If no secretion is secured by massaging the prostate and seminal vesicles the patient is asked to void again frequently it is found that the expressed secretion has been forced backward into the bladder

**Symptomatology and Diagnosis**—Urethral discharge burning or tingling on urination lumbar pains loss of erections and sexual neurasthenia are common symptoms of prostatitis and seminal vesiculitis The symptoms are often vague and variable and one must undertake a careful examination in order to rule out other pathologic processes which cause similar symptoms Prostatitis must be differentiated from posterior urethritis verumontanitis papilloma of the vesical neck and the rare conditions such as tuberculosis cysts and leukoplakia

The prostate is more frequently infected than the vesicles probably in the ratio of 10 to 1 The complication of epididymitis points very strongly to the vesicle as the site

of infection Hematospermia and nocturnal emissions of blood stained semen are symptoms either of chronic seminal vesiculitis or of inflammation of the verumontanum or both The latter can be ruled out by careful inspection with the cystourethroscope The ejaculatory ducts may be stenosed or completely closed by inflammation or scar tissue Sometimes they can be successfully probed through the urethroscope and made to function

The vesicles are rarely involved in chronic inflammation without involvement of the prostate except in tuberculosis This simplifies the burden of diagnosis because the treatment is much the same except in certain persistent types of vesiculitis in which surgical procedures are necessary for relief In many cases a prostate that feels normal as to size texture and consistency and that may be free from tenderness on pressure is chronically inflamed and contains many pus cells An infected vesicle is sensitive or painful to palpation Certain areas of increased hardness in the prostatic lobes or in the region of the most lateral portions of the prostatic capsule will lead the examiner to suspect carcinoma The age of the patient should be considered since chronic prostatitis is most frequently found in middle life and malignant growths are more frequent beyond the age of fifty years

We have now learned that cancer of the prostate may be undiagnosed for several years Keves has pointed out the fact that pain along the sciatic nerve on one side is suggestive of cancer of the prostate and when bilateral is pathognomonic Particularly is there apt to be found a hard almost boardlike area in the region of one or both vesicles in chronic perivesiculitis The vesicles are not so commonly the seat of cancer as is the prostate

Early cancer and chronic prostatitis with interstitial changes are difficult to differentiate Any area of hardness irregularity or nodule formation in the prostate of a patient past middle life should be considered as probably cancer until its character is determined by biopsy As carcinoma of the prostate advances one meets some difficulty in introducing a cystoscope through the prostatic urethra encountering hardened tissues and irregularities The trigone of the

bladder may be elevated. A roentgenogram of the pelvic bones, spine and lungs may show metastases.

If a definite amount of pus can be demonstrated in the expressed secretion in a doubtful case, gentle treatment for chronic prostatitis may be instituted for a few weeks before a biopsy is taken. In the writer's experience a number of such cases have yielded to mild therapeutic measures, proving them to be chronic inflammatory infiltrations and not new growths. If any suspicious nodules appear in the cystoscopic picture at the vesical neck, they can be easily and safely removed by the resectoscope for examination without the hazard of metastasis.

A chronically inflamed prostate may develop an increase of interstitial tissue compressing the prostatic urethra and resulting in slowness of the urinary stream and painful and frequent urination. These symptoms are much the same as those caused by prostatic hypertrophy with partial obstruction.

**Treatment**—Before treatment is begun a careful examination of the upper urinary tract is often advisable. Meatotomy should be performed if the urethral meatus will not admit a no. 27 French sound. Gradual dilation of the prostatic urethra is necessary to relieve the irritation in the prostatic urethra, to open the prostatic ducts and to help empty their contents. This also improves the circulation and aids the absorptive process in the gland itself.

The treatment which has been most successful in chronic prostatitis consists of gentle massage followed by lavage of the urethra and bladder with a mild antiseptic such as 1 to 1000 silver nitrate or 1 to 2000 copper sulfate. The lavage of the urethra and bladder serves to wash out the prostatic and vesicular detritus which is a potential source of urethritis and cystitis. Massage should not be carried out too frequently; a three to five day interval is best in ordinary prostatic infections, with a longer interval as the infection subsides. If pain is experienced or if blood tinged secretion is obtained longer intervals and less vigorous massage are indicated. In certain instances there may be cavity formation and prostatic calculi present and these should be removed. However, the chronically infected prostate is

rarely a surgical problem. Heat applied by hot sitz baths, irrigators or electrical apparatus directed to the prostate through the rectum and diathermy has been of great benefit.

It has been the fond hope of every urologist that chemotherapy would be found effective in sterilizing the chronically infected prostate, but little improvement has been noted from the use of sulfonamides or penicillin. The dyes represented by pyridium, mallophone and seranium are excreted to some degree in the prostatic contents and these drugs may have some beneficial influence in reducing the infection in the prostate and vesicles. On the whole, however, systemic treatment with drugs has been consistently disappointing.

After treatments have been carried out over a long period, a few patients will remain uncured and the prostate and vesicles may be a menace to the general health. Some suppurating pockets in the prostate may require open surgical drainage and in certain cases of arthritis in which the vesicles are thickened and contain pus, vesiculotomy or vesiculectomy may be necessary by the method of Fuller or the method so clearly described and expertly performed by Hugh Young. This will be necessary in only a very few cases but if they are properly selected, brilliant results may be expected.

CARUS F. BURFORD

## OTHER AFFECTIONS OF THE PROSTATE

### PROSTATIC ABSCESS

Henceforth, abscess of the prostate has generally been considered as a complication of gonorrhea. However, it is well to bear in mind that a great many of these cases are metastatic in origin and that abscess of the prostate has followed the passage of sound, bougies and cystoscopes and the use of strong injections. Again, abscess of the prostate has been noted as a complication of such general infectious diseases as typhoid fever, mumps and influenza. Among other causes of suppuration that the writer has seen are furuncle, carbuncle, acute and chronic osteomyelitis and paronychia, as well as acute tonsillitis. Abscess of the pros-

tate may be associated with benign hypertrophy but this is very rare. Abscess has followed cases of urethral stricture due to poor and insufficient urethral drainage. Abscess also frequently occurs as a complication of acute urethral gonorrhea and the gonococcus is found in the pus. In the non-venerical cases staphylococcus is the most frequent organism. It may occur alone or associated with streptococci and colon bacilli.

**Symptoms and Diagnosis.**—There is no difference in the symptoms whether the abscess is of gonorrheal or non-gonorrheal origin except that in gonorrheal cases a urethral discharge is present which shows gonococci. Loss of appetite and a feeling of malaise soon follow. The temperature may rise to  $104^{\circ}$  or  $105^{\circ}$  F and is often associated with one or more chills. Pain is a constant symptom and may be due to the abscess itself or to distention of the bladder in cases in which complete retention of urine occurs. Perineal pain may occur and is often accompanied by a feeling of fullness. Frequency of urination is present in practically all the cases and may vary from a slight increase in frequency to a state in which the desire to void is so urgent that the patient is obliged to empty the bladder every fifteen to thirty minutes. Retention of urine is quite common. Complete retention in a young man should always arouse suspicion that the condition may be due to abscess of the prostate. Retention occurs with equal frequency both in venereal and non-venereal cases. Abscess may cause obstruction at the neck of the bladder so that difficulty of urination occurs necessitating straining in order to start the stream. Rectal symptoms such as pain on defecation with a feeling of warmth and fullness may be present.

Rectal examination shows definite changes in the prostate. Examination usually is very painful. The prostate is increased in size and feels hot and tense and in some of the cases fluctuation can be elicited. When the abscess is small there may be some question about the diagnosis but in ordinary cases the rectal examination is quite convincing. Leukocytosis is present. In some of the cases a mild eosinophilia occurs.

The three possible terminations of an abscess of the prostate are resolution, rupture or surgical drainage. Cases that have gone on

to resolution are extremely rare though this is possible and does occur in some instances. By far the largest number terminate by rupture into the urethra or into the rectum and occasionally into the bladder. Rupture along side the rectum may develop into a perirectal abscess.

**Treatment.**—Hot sitz baths, hot rectal irrigations and heat applied in the form of wet dressings to the suprapubic region and perineum give the patient a great deal of relief. In some instances it is necessary to use morphine or codeine by mouth. A rectal suppository containing belladonna or opium is often decidedly beneficial. When these measures fail to give the desired relief and when the presence of fluctuation can be demonstrated on rectal examination operation is in order. The abscess should be drained by means of a perineal prostaticotomy. At the time of operation careful examination should be made so as not to overlook a second abscess or abscesses in the opposite lobe. In some of these cases because of the presence of pus in the prostate after the wound is healed it is necessary to institute prostatic massage and advise the patient to continue heat per rectum. The sulfadiazine drugs are without value in the treatment.

### CYSTS OF THE PROSTATE

Cysts of the prostate are rare. They may occur in the newborn and in children as well as in adults. Some authors are of the opinion that they are due to closure of the Wolffian tubules. In the newborn these cysts project into the urethra and produce obstructions to urination so that micturition is deferred for several days after birth.

**Etiology.**—According to von Frisch midline cysts originate from Muller's ducts while cysts placed laterally take their origin from remnants of the Wolffian body. Retention cysts may be due to narrowing or closure of the prostatic ducts or may result from the fibrous tissue following inflammation in the prostate or urethra. The walls of these cysts are smooth and thin and the cysts themselves are found to be more or less transparent when examined with the cystoscope.

**Symptoms.**—With all cysts of the prostate produce the same symptoms. When large they may cause obstruction to the outflow of urine. In the adult they are occasionally confused with benign hypertrophy because of the symptoms of obstruction which they produce.

**Treatment.**—The treatment consists in destruction of the cyst by means of fulguration through the cystoscope.

**Echinococcus Cyst.**—Echinococcus disease rarely affects the prostate. When this condition is encountered in the perineal region it is generally found between the bladder and the rectum. The cyst may reach an

enormous size and interfere with urination and in rare instances it may cause complete retention. The eel-inococcus or myelomeli fixation test is of great aid in diagnosis. The treatment is surgical.

Other tumors of the prostate except sarcoma, carcinoma and benign hypertrophy are rare.

### PROSTATIC CALCULI

Prostatic calculi may be classified as being either true or false. True prostatic calculi are situated within the substance of the prostate. False prostatic calculi are urinary calculi that have become lodged in the prostatic urethra and really do not belong to the group of true prostatic stones.

**Etiology**—True prostatic calculi have their origin within the prostate itself. They consist in the main of phosphates, carbonates or deposits of lime, magnesium or triple phosphates. The etiology has not been definitely determined. Three theories have been advanced to explain their origin: (1) It is believed by many authors that the stones are due to a mild chronic infection of the excretory ducts of the gland; (2) others are of the opinion that these calculi are formed by deposits of salts around a nucleus composed of normal prostatic secretion while (3) still others believe that prostatic calculi are formed by accumulations of corpora amylicia.

Prostatic stones are rare in patients under twenty years of age. Gonorrhea and syphilis have no etiologic bearing.

**Symptoms**—For the purpose of discussion the symptoms may be divided into three groups:

1 Cases in which calculi are found in a more or less accidental manner during a routine physical examination and in which the calculi do not produce any symptoms.

2 In this group may be placed the cases in which calculi are associated with benign hypertrophy of the prostate. The clinical picture is that of benign prostatic hypertrophy. The stones may be located within the gland structure proper or may be found between the hypertrophied gland and its capsule.

3 A group of cases in which the symptoms are due to the presence of calculi and the patient seeks relief because of the distress incident to the disorder. It is this group that is usually meant when the subject of prostatic calculi is discussed.

In nearly all the patients pain is present at some time or other during the course of the disease although in rare instances it may be absent. It may be localized to the prostate or referred to the perineum, urethra, penis, scrotum, anus or suprapubic area. rarely does pain extend to the posterior surface of the thigh. When pain is present in the perineum it is greatly aggravated by sitting on a hard surface. In the occasional case a history of the passage of prostatic calculi *per urethram* is given. Abscess formation with or without fistula is rare. The urinary symptoms naturally predominate. The patient complains of painful urination, burning, dribbling and difficulty in starting the stream. Sexual symptoms are rare but loss of potency has been recorded in some cases.

Rectal symptoms such as tenesmus, pain in the rectum and painful defecation are not unusual symptoms. In the occasional case stricture of the urethra may occur.

**Diagnosis**—Stones in the prostate can be definitely established in every case by means of roentgenograms and stones in the prostate may be found in cases in which the usual symptoms are absent. As a rule multiple shadows are present. They may be located on one or the other side of the midline just above the symphysis pubis or they may occur on both sides of the midline. Their grouping is not always constant.

Next to roentgenograms in value from the standpoint of diagnosis is the rectal examination. When the stones are large they can be felt with the examining finger and a sense of crepitation is obtained. This however is not always evident. Areas of great hardness should always arouse suspicions of the possible presence of calculi and a roentgenogram should be taken for the reason that calculi are frequently overlooked during a rectal examination.

**Treatment**—The treatment varies somewhat in each case. Small multiple calculi that are not producing symptoms but are discovered during a routine examination do not call for radical treatment. Stones associated with benign hypertrophy can be treated at the time when prostatectomy is performed.

In the third group of cases that is the group in which the patients have symptoms, radical removal of the calculi can best be performed by perineal prostatotomy. It is



tate may be associated with benign hypertrophy but this is very rare. Abscess has followed cases of urethral stricture due to poor and insufficient urethral drainage. Abscess also frequently occurs as a complication of acute urethral gonorrhea and the gonococcus is found in the pus. In the non-veneral cases staphylococcus is the most frequent organism. It may occur alone or associated with streptococci and colon bacilli.

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to resolution are extremely rare though this is possible and does occur in some instances. By far the largest number terminate by rupture into the urethra or into the rectum and occasionally into the bladder. Rupture along the rectum may develop into a perirectal abscess.

**Treatment.**—Hot sitz baths, hot rectal irrigations and heat applied in the form of wet dressings to the suprapubic region and perineum give the patient a great deal of relief. In some instances it is necessary to use morphine or codeine by mouth. A rectal suppository containing belladonna or opium is often decidedly beneficial. When these measures fail to give the desired relief and when the presence of fluctuation can be demonstrated on rectal examination operation is in order. The abscess should be drained by means of a perineal prostaticotomy. At the time of operation careful examination should be made so as not to overlook a second abscess or abscesses in the opposite lobe. In some of these cases because of the presence of pus in the prostate after the wound is healed it is necessary to institute prostatic massage and advise the patient to continue heat per rectum. The sulfadiazine drugs are without value in the treatment.

### CYSTS OF THE PROSTATE

Cysts of the prostate are rare. They may occur in the newborn and in children as well as in adults. Some authors are of the opinion that they are due to closure of the sinus peculiaris. In the newborn these cysts project into the urethra and produce obstructions to urination so that micturition is deferred for several days after birth.

**Etiology.**—According to von Frisch, midline cysts or glands from Muller's ducts while cysts placed laterally take their origin from remnants of the Wolffian body. Retention cysts may be due to narrowing or closure of the prostatic ducts or may result from the fibrous tissue following inflammation in the prostate or urethra. The walls of these cysts are smooth and thin and the cysts themselves are found to be more or less transparent. I have examined with the cystoscope.

**Symptoms.**—When small cysts of the prostate produce few symptoms. When large they may cause obstruction to the outflow of urine. In the adult they are occasionally confused with benign hypertrophy because of the symptoms of obstruction which they produce.

**Treatment.**—The treatment consists in destruction of the cyst by means of fulguration through the cystoscope.

**Echinococcus Cyst.**—Echinococcus disease rarely affects the prostate. When this condition is encountered in the perineal region it is generally found between the bladder and the rectum. The cyst may reach an

enormous size and interfere with urination and in rare instances it may cause complete retention. The echinococcus complement fixation test is of great aid in diagnosis. The treatment is surgical.

Other tumors of the prostate except sarcoma, carcinoma and benign hypertrophy are rare.

### PROSTATIC CALCULI

Prostatic calculi may be classified as being either true or false. True prostatic calculi are situated within the substance of the prostate. False prostatic calculi are urinary calculi that have become lodged in the prostatic urethra and really do not belong to the group of true prostatic stones.

**Etiology**—True prostatic calculi have their origin within the prostate itself. They consist in the main of phosphates, carbonates or deposits of lime, magnesium or triple phosphates. The etiology has not been definitely determined. Three theories have been advanced to explain their origin: (1) It is believed by many authors that the stones are due to a mild chronic infection of the excretory ducts of the gland; (2) others are of the opinion that these calculi are formed by deposits of salts around a nucleus composed of normal prostatic secretion; while (3) still others believe that prostatic calculi are formed by accumulations of corpora amylicca.

Prostatic stones are rare in patients under twenty years of age. Gonorrhea and syphilis have no etiologic bearing.

**Symptoms**—For the purpose of discussion the symptoms may be divided into three groups:

1. Cases in which calculi are found in a more or less accidental manner during a routine physical examination and in which the calculi do not produce any symptoms.

2. In this group may be placed the cases in which calculi are associated with benign hypertrophy of the prostate. The clinical picture is that of benign prostatic hypertrophy. The stones may be located within the gland structure proper or may be found between the hypertrophied gland and its capsule.

3. A group of cases in which the symptoms are due to the presence of calculi and the patient seeks relief because of the distress incident to the disorder. It is this group that is usually meant when the subject of prostatic calculi is discussed.

In nearly all the patients pain is present at some time or other during the course of the disease, although in rare instances it may be absent. It may be localized to the prostate or referred to the perineum, urethra, penis, scrotum, anus or suprapubic area, rarely does pain extend to the posterior surface of the thigh. When pain is present in the perineum it is greatly aggravated by sitting on a hard surface. In the occasional case a history of the passage of prostatic calculi *per urethram* is given. Abscess formation with or without fistula is rare. The urinary symptoms naturally predominate. The patient complains of painful urination, burning, dribbling and difficulty in starting the stream. Sexual symptoms are rare, but loss of potency has been recorded in some cases.

Rectal symptoms such as tenesmus, pain in the rectum and painful defecation are not unusual symptoms. In the occasional case stricture of the urethra may occur.

**Diagnosis**—Stones in the prostate can be definitely established in every case by means of roentgenograms and stones in the prostate may be found in cases in which the usual symptoms are absent. As a rule multiple shadows are present. They may be located on one or the other side of the midline just above the symphysis pubis or they may occur on both sides of the midline. Their grouping is not always constant.

Next to roentgenograms in value from the standpoint of diagnosis is the rectal examination. When the stones are large they can be felt with the examining finger and a sense of crepitation is obtained. This however is not always evident. Areas of great hardness should always arouse suspicions of the possible presence of calculi and a roentgenogram should be taken for the reason that calculi are frequently overlooked during a rectal examination.

**Treatment**—The treatment varies somewhat in each case. Small multiple calculi that are not producing symptoms but are discovered during a routine examination do not call for radical treatment. Stones associated with benign hypertrophy can be treated at the time when prostatectomy is performed.

In the third group of cases that is the group in which the patients have symptoms, radical removal of the calculi can best be performed by perineal prostatotomy. It is

necessary to remove all the stones in order to prevent a recurrence and of equal importance to explore the cavity and break up any

enlargement of the prostate it results in obstruction at the neck of the bladder with secondary changes in the bladder and upper

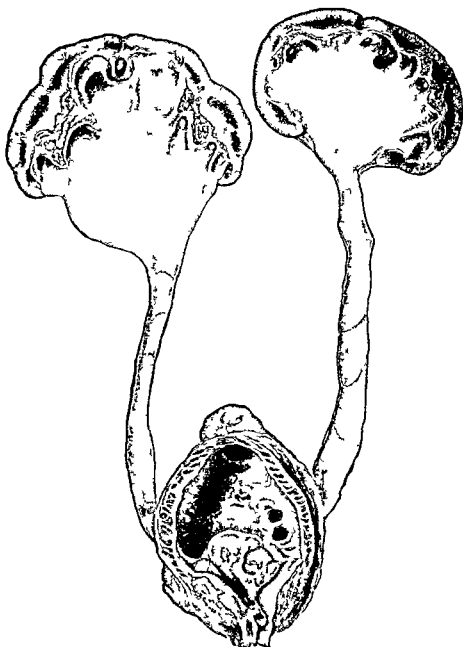


Fig. 664.—Showing the presence of a large middle lobe hypertrophy with resulting dilatation of the ureters and marked hydronephrotic atrophy of the kidneys.\*

adhesions that may be present so as to prevent the formation of more stones.

#### BENIGN HYPERTROPHY

**Definition**—Benign hypertrophy is a disease of the prostate that is rare before the age of fifty and occurs with greatest frequency after fifty-five. It is characterized by

enlargement of the prostate and it is accompanied by difficulty in urination. It has a progressive course and is fatal unless relieved by appropriate treatment.

**Etiology**—Advanced age is the one factor that is always present. The majority of the

\* Lewis: Practice of Surgery. W. F. Prior Co. Publishers.

patients being between fifty five and seventy years of age. After seventy the incidence of this disease decreases. The oldest patient the writer has seen with prostatic obstruction was ninety nine years and ten months old. Gonorrhea and syphilis play no role in the development of this disease. Formerly it was thought that gout, rheumatism and alcohol played a predominant role but this is not true. Heredity is unimportant, although there seems to be a tendency for this condition to occur in families. On one occasion the writer had as patients in the hospital at the same time three brothers who were suffering from benign hypertrophy.

Various theories have been advanced from time to time to explain the cause of hypertrophy. 1. The arteriosclerotic theory was promulgated by the French school of urologists who considered the hypertrophy to be due to or a manifestation of arteriosclerosis that involved

origin of hypertrophy. 6. Deming from his investigations is of the opinion that the early changes of benign enlargement of the prostate in man are primarily due to a multiplication of the fibromuscular elements.

**Pathology.**—The enlargement of the gland varies within very wide limits. Attention may be called to the fact that the size of the prostate has nothing to do with the severity of the symptoms nor the degree of obstruction. An unusually large prostate may produce only mild disturbance while, on the other hand, a very small adenoma at the internal urethral orifice may produce exceedingly severe symptoms.

Much discussion still centers around the question of whether benign hypertrophy is a true neoplasm or a hyperplastic process. The majority of urologists believe that it is due to hyperplasia and is not a true tumor formation.

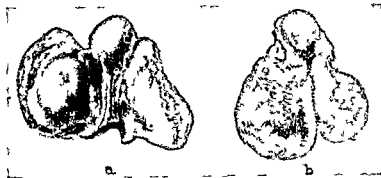


Fig. 665.—a Trilobar hypertrophy of the prostate b showing the groove made by the internal sphincter with intravesicular protrusion of the middle lobe.

not only the prostate gland but the bladder and kidneys as well. 2. The inflammatory theory has but few advocates at the present time. The English surgeon Thompson was one of the earliest authors to believe that inflammatory changes in the prostate played no role in the etiology. Several years ago the interest in the inflammatory origin of hypertrophy was revived by the work of Ciechanowski who believed that hypertrophy and also certain form of prostatic atrophy are due to chronic inflammatory changes in the prostate. This theory has practically no adherents today. 3. The neoplastic theory was upheld by Virchow who was of the opinion that so-called hypertrophy is caused by a true tumor formation. However, the question of whether or not true hypertrophy is a new growth or is due to hyperplasia is still a much disputed point. 4. Disturbed physiology is considered by some authors to be the cause of hypertrophy. This opinion is based on the fact that hypertrophy occurs at a time of life when the function of the testicle is on the wane, the hypertrophy being considered as a compensatory function for the diminished or diminishing sexual function. 5. At the present time a good deal of thought and investigation is being directed to the possible endocrine

**Types of Enlargement.**—Tandler and Zuckerkindl have divided hypertrophy into two groups—intravesical and subvesical.

**Intravesical Type.**—The internal urethral orifice is changed both in shape and in position. The size of the enlargement varies from that of a small plum to that of a lemon or it may be larger. It may be more or less pedunculated or it may completely surround the internal urethral orifice hence its outline may be either regular or irregular. The enlargements are most marked on the sacral side of the internal urethral orifice. Cases in which the enlargement entirely surrounds the urethral orifice have been compared to the cervix uteri. The internal urethral orifice is always elevated above its normal location. A groove caused by the compression of the internal sphincter may be seen in the specimen removed by suprapubic prostatectomy.

**Subvesical Type.**—Under this type Tandler and Zuckerkindl group all cases in which the protrusion is below the internal sphincter. There is no intravesical protrusion but the internal urethral orifice is enlarged.

**Point of Origin.**—At the present time the general consensus of opinion is to the effect that the hypertrophy takes its origin from the accessory glands.

from the tubules and not from the prostatic gland proper. Among the authors who are of this opinion may be mentioned Rokitanaky, Jores, Tanller and Zuckerkandl, Blum and Rubrins. Lawsley states that these glandular tubules are present in the ampulla in the embryo after the sixteenth week. Others share this view. Motz and Perearnau are of the opinion that the origin of prostatic hypertrophy is from the central group of tubules and that the prostate itself does not take part in the formation of the tumor.

**Gross Description**—The size of the enlarged prostate may vary within wide limits. Prostates have been removed that weighed as much as 500 Gm. The writer has removed a small prostate that weighed 90 grams which produced complete obstruction. The enlargement, as a rule, is uniform although one lobe may be larger than the other. The surface is smooth and surrounded by a smooth capsule and the consistency is elastic. The cut surface is light in color and connective tissue septa are seen running in from the periphery. Prostatic fluid exudes from the cut surface. When the prostate is infected small milary abscesses may be seen on the cut surface.

**Microscopic examination** shows the presence of an epithelial hyperplasia with the formation of villi in some cases. The presence of cystic dilatation of the acini is noted in a large number of instances. The epithelial lining of the acini may be flattened and as the dilatation increases they become more and more compressed so that only the nuclei can be seen. The lumen of the tubules may be filled with finely granular material that contains leukocytes and starch granules. Desquamated epithelial cells are also evident. The changes in the stroma vary from a slight overgrowth in the connective tissue to a great increase in the fibrous tissue, periglandular round cell infiltration often being seen.

**Changes Due to Obstruction**—That elongation of the prostatic urethra occurs was recognized many years ago and was utilized as an aid in diagnosis. Instead of the normal curve of the prostatic urethra it forms in some cases a right angle with the lateral lobes which protrude irregularly into it so that it has an S shaped curve. At times the wall of the bladder may be very greatly thickened this occurs at the expense of the bladder capacity so that a small contracted bladder results (concentric hypertrophy). The muscle bundles also undergo hypertrophy and show elevations above the surface which are delicate in character and few in number at first. As the disease progresses the elevations increase in size and number and become very thick and coarse. Sooner or later cellular formation occurs.

Diverticuli often very large are not uncommon. Dilatation of the ureter and renal pelvis occurs in various degrees. If the ob-

struction is allowed to persist complete atrophy of the kidneys may result.

**Relationship of Benign Hypertrophy to Carcinoma of the Prostate**—Opinion is divided on this point. Some authorities believe that carcinoma may take its origin in the enlarged lateral lobes. Geraghty on the other hand was firm in the belief that carcinoma always begins in the posterior lobe that is in the portion of the prostate not involved in the hypertrophy.

**Median Bar**—The interest in median bar formation began with the publication of a monograph by Guthrie in 1830. In this group of cases the symptoms are practically the same as those produced by large hypertrophies. Rectal examination reveals a prostate that is normal in size although not infrequently it has been found to be smaller than normal. The term prostatism has been in use for many years to describe this type of case. The classification given by Randall as a result of much careful work is as follows:

**TYPE I**—A bar fibrous in type arising from or stretched across the posterior lip of the vesical orifice. This type produces shortening of the distance from the vesical orifice to the verumontanum.

**TYPE II**—A fibrous bar, the projection of which is upward or toward the bladder and seems to encroach on the vesical trigone.

**TYPE III**—A glandular bar in which the hypertrophied process is confined to the glandular acini of the posterior prostatic commissure inside the prostatic capsule under the sphincter muscle so that the posterior vesical lip is raised into a thick broad heavy obstructing bar.

**TYPE IV**—Isolated hypertrophy of the subcervical glands of Albarran.

**Symptoms**—The symptoms in this group of cases are practically identical with those produced by hypertrophy. The patients have frequency and difficulty of urination and attacks of acute retention of urine. Residual urine in varying amounts is present.

Rectal examination reveals a small prostate often smaller than normal and cystoscopic examination fails to show the presence of an intravesical hypertrophy.

The gradual onset and slow progress are characteristic manifestations of this disease.

One symptom that is always present is

frequency of urination that is mild in the early stages and slow in progress. Nocturnal frequency of urination is characteristic of prostatic obstruction. Early in the course of the disease the patient may void only once or twice at night but later it is often necessary to void every half hour or hour.

Difficulty of urination is not very marked early in the course of the disease but is progressive and the patient often finds it difficult to start the stream in some instances the patient can pass only a few drops of urine with the greatest effort. The difficulty may be overcome by changes in posture. In some instances the patient is obliged to wait one or two or even three minutes before he can start the stream. Lack of force is often accompanied by loss of power of projection so that the patient is compelled to stand close by during urination.

Drizzling at the end of the act is complained of by many patients an inconvenience which may also be due to incontinence resulting from overflow, so called paradoxical incontinence.

**Hematuria.**—Gross bleeding is not a common symptom. Blood at the end of urination often associated with straining has been noted. When profuse bleeding occurs the bladder may become filled with clots. The bleeding may be aggravated or increased by the passage of instruments.

**Polyuria.**—In some instances the patient may have an associated polyuria and may pass large quantities of urine as much as 4 or 5 liters during twenty-four hours.

**Pain.**—Pain referred to the urethra and associated with the act of urination is present in from 75 to 80 per cent of cases. It varies in degree from a mild burning sensation along the urethra to severe pain. The pain may be referred to the neck of the bladder, the perineum, the end of the urethra or the back, thighs or rectum.

**Complete Retention of Urine.**—Complete retention of urine in the prostatic patient may be induced by constipation, exposure to cold, chilling of the body and putting the feet wet. Overindulgence in alcohol and long automobile trips often induce an attack of complete retention. Acute infectious processes such as influenza, coryza and tonsillitis have been followed by acute complete retention.

**Sexual Symptoms.**—As a rule the sexual symptoms are not very prominent. Because of the age of the patient there is more or less diminution of sexual vigor. In some instances the decided improvement in the patient's general health following removal of the prostatic obstruction results in a return of a degree of sexual vigor. Repeated attacks of acute epididymitis occur in some patients before they are seen by the physician.

**Gastrointestinal Symptoms.**—Gastrointestinal symptoms are not always present but when they are it is generally late in the course of the disease. Loss of appetite occurs in the later stages particularly in cases in which there is an associated severe infection of the urinary tract. Excessive thirst with associated polyuria is seen at times. Constipation is a frequent symptom and in some cases is due to the enormously enlarged prostate which mechanically interferes with the act of defecation. Hemorrhoids are often present in cases characterized by severe tenesmus and great obstruction. In some cases prolapse of the rectum has been noted. Inguinal hernia is not an uncommon symptom and is no doubt due to the excessive straining which is incident to the obstruction.

**Cardiovascular Symptoms.**—A large number of patients suffer from various cardiovascular symptoms such as angina pectoris, hypertension, arterio-sclerosis, myocarditis and coronary disease. In a recent survey of 100 patients 63.41 per cent had associated organic disease of the cardiovascular system.

**Complications.**—The most frequent complication of prostatic obstruction is infection which may be limited to the bladder or may involve the kidneys and ureters as well.

Naturally because of the presence of residual urine cystitis is the most common complication of prostatic obstruction. Local conditions which are favorable for infection are residual urine, chronic distention of the bladder and hyperemia of the mucous membrane so that the passage of a sound catheter or cystoscope is often followed by acute cystitis.

In patients who have not had instrumentation urethritis is rarely present. On the other hand a patient who is under treatment with an indwelling catheter may acquire so called catheter urethritis. This is

due to the presence of a catheter which acts as a foreign body to the fact that the catheter prevents the escape of normal urethral secretion and furthermore to the fact there is no flushing of the urethra by the urine. *Epididymitis* is a relatively frequent complication of prostatic obstruction. It has been variously estimated that epididymitis occurs in from 20 to 25 per cent of all patients including the occurrence of epididymitis before as well as after operation.

*Diverticula*—Diverticula of the bladder with benign obstruction are not uncommon. It is important to recognize the presence of a diverticulum before treatment is undertaken. In certain cases failure to remove the diverticulum is responsible for the persistence of pyuria following removal of the obstruction.

*Stone*—Stone in the bladder is a relatively common complication. Prostatic stones are uncommon; nevertheless stones may be found associated with obstruction without the presence of infection. Stone formation following prostatectomy is not a frequent occurrence although the persistence or recurrence of symptoms following removal of the obstruction should always arouse suspicion as to the possible presence of stones.

*Renal Complications*.—Acute pyelitis may occur following the passage of a catheter. It may occur immediately before or directly after operation and it is characterized by a sudden onset of severe chill, high fever and pain in the renal area. Chronic pyelitis occurs in patients with dilatation of both renal pelvis and ureters. The infection is probably not limited to the pelvis but involves the renal parenchyma producing chronic pyelonephritis.

Hydronephrosis probably occurs more frequently than is suspected as is evidenced by the fact that intravenous pyelograms frequently show the presence of hydronephrosis when it is not suspected. Suppurative pyelonephritis with the formation of small milky abscesses may develop. These abscesses may be hematogenous in origin or they may be the result of extension of infection along the lumen of the ureter from the bladder. Abscess of the prostate associated with hypertrophy is relatively rare. Stones may be found in the prostate but they are generally small and are located beneath the capsule.

*Diagnosis*—The symptoms of prostatic obstruction are typical and a definite diagnosis may be made from the history and physical examination although in a few cases the general symptoms may overshadow the disturbances of urination.

*Rectal Examination*—Rectal examination yields valuable information regarding the size, shape and consistency of the prostate. It is probably the most satisfactory method of examination by which to establish a correct diagnosis. Generally the two lateral lobes are equally enlarged although not necessarily so in every case. In some cases the enlargement is only moderate; in others the enlargement may fill the bony pelvis. The surface is generally smooth and the margins are sharply defined. In cases associated with much infection there is evidence of periprostatitis. The consistency which is characteristic of benign hypertrophy is softness and elasticity. Despite the fact that rectal examination gives an amount of information that is invaluable it fails to yield information regarding the amount of enlargement which may be present within the bladder or within the urethra.

*Estimation of Residual Urine*—This is a relatively simple procedure and when properly performed it yields a great deal of information regarding the patient's ability to empty the bladder. Estimation for residual urine (the amount obtained by catheterization after the patient has voided) should be carried out under strictest antiseptic precautions. Next to the rectal examination it is the most important diagnostic procedure.

*Changes in the Urethra*—Formerly a great deal of stress was laid on the measurement of the posterior urethra as an aid in the diagnosis of benign hypertrophy. While this is of anatomical interest it is of little use as an aid in establishing the diagnosis.

*Cystography*—Cystograms may be made with a sterile solution of potassium bromide or iodide. The strength used varies from 5 to 15 per cent. The cystogram shows the size of the bladder and the changes in its outline. It occasionally reveals the presence of diverticula where least expected and in some instances the reflux of the solution up the ureter shows the presence of a large hydronephrosis and hydronephrosis.

**Intravenous Pyelography**—While not necessary in every case intravenous pyelography often shows the presence of unsuspected diverticula or hydronephrosis.

**Cystoscopic Examination**—Examination of the vesical orifice with the cystoscope and with the rectoscope yields information regarding the intravesical and intraurethral type of hypertrophy. These methods of examination demonstrate very clearly whether there is enlargement of the lateral lobes, bars or median lobes, etc., and may reveal the presence of stone, benign or malignant tumors and diverticula. These procedures must be carried out with a certain amount of care and under the strictest antisepsis and asepsis possible. It is best not to examine a patient who has a severe infection or a large amount of residual urine without some preliminary treatment.

**Differential Diagnosis**—1 *Carcinoma*—In the largest number of patients differentiation between benign hypertrophy and carcinoma is relatively simple and easy, although in some cases a small area of carcinoma located in a large lateral lobe may be overlooked on rectal examination. A carcinomatous prostate always shows changes in consistency, varying from areas of the slightest increased consistency to a degree of hardness that has been described as stony. Irregularities in outline are often present, and the tendency for carcinoma to extend beyond the confines of the prostate is well known. The seminal vesicles are often involved early and the intervesicular space is infiltrated by the carcinoma.

2 *Chronic Prostatitis*—Patients with chronic prostatitis often have only slight enlargement of the prostate. Strippings give a large amount of pus. The absence of residual urine and careful cystoscopic examination are important and constitute indispensable aids in the making of a differential diagnosis.

3 *Calculi* may be associated with benign hypertrophy. Rectal examination often elicits areas that are very hard in consistency and a sense of crepitation may be present. Roentgenographic examination is an invaluable aid.

4 *Abscess of the prostate* is rare. Rectal examination reveals fluctuation in one or both lobes. The patient often has acute

symptoms sudden in onset accompanied by chills, fever and sweats.

5 *Sarcoma of the prostate* is rare and gives a peculiar sensation to the finger on rectal examination when present.

6 *Echinococcus disease* of the prostate can be differentiated by the echinococcus complement fixation test.

7 *Lesions of the Central Nervous System*—It is well known that lesions of the central nervous system produce urinary symptoms that may be confused with prostatic hypertrophy. It must not be forgotten that lesions of the central nervous system can be associated with benign hypertrophy. In ordinary differentiation rectal examination shows the absence of hypertrophy of the lateral lobes and loss of tone in the rectal sphincter, the knee jerks are absent and there is an Argill Robertson pupil. If any doubt exists a Wassermann test of the blood or spinal fluid should be made. Cystoscopic examination is of great aid.

8 *Strictures of the urethra* may be associated with or confused with benign hypertrophy, although as a rule stricture of the urethra is uncommon in persons at prostatic age. The presence of stricture can be demonstrated by exploration of the urethra with diagnostic bougies.

9 *Lesions of the kidney* are rarely confused with benign hypertrophy. In rare instances malignant tumor of the kidney may be associated with benign hypertrophy.

**Prognosis**—Benign hypertrophy is a progressive disease and unless the obstruction is removed leads to death of the patient. This fatality is not due to the disease *per se* but to the complications following in the wake of the obstruction, such as infection and uremia. With removal of the prostate the prognosis is good.

**Treatment**—1 *Prophylactic Treatment*—At the present time there is no treatment that will prevent enlargement of the prostate.

2 *Non Operative and Hygienic Treatment*—Chilling of the body should be avoided and the feet should be kept dry and warm. The skin should be protected with warm underwear in cold weather. Long cold automobile trips as well as sitting on damp ground or cold stones should be avoided. The patient should be encouraged



tatectomy is performed. Bleeding may be controlled by suture or by the use of a rubber bag or a gauze pack. Hemorrhage occasionally occurs two weeks after operation and then is always due to infection.

**Complications of surgical prostatectomy** are shock, pyelitis, fistula, dilatation of the stomach, bronchitis, pneumonia, pulmonary embolism and phlebitis. Cardiac complications occur less frequently than formerly because of a more careful preoperative study of the patient with heart disease. Cerebral thrombosis is rare. Coronary occlusion, attacks of angina and myocardial failure are uncommon.

Urogenital complications developing after operation are acute epididymitis which occurs in 20 per cent of the cases, stricture of the urethra which is more frequent after perineal than after suprapubic prostatectomy, and occasionally fistula after either suprapubic or perineal prostatectomy. Incontinence of urine is rare. Impotence occurs in a small number of cases, and when it does it is generally permanent. Stone in the bladder must be considered as a rare complication occurring in about 2 per cent of cases. Recurrence following complete removal of the prostate is rare, but it does occur. It is characterized by the fact that a long interval exists between the removal of the prostate and the development of the symptoms of recurrence.

The mortality has been variously estimated at from 4 to 9 per cent.

**Transurethral Resection**—At the present time transurethral resection is the method most frequently used to relieve prostatic obstruction. Its advantages are an exceedingly low mortality rate, the short period of postoperative hospitalization and the applicability of this technique to patients who heretofore have been denied relief of symptoms because they were poor surgical risks. The mortality varies from 1 to 2 per cent. I have performed 238 consecutive resections with 1 death. Perfect hemostasis is most important here as in any surgical procedure. It is needless to emphasize that complete removal of the obstruction is imperative. I never fol-

low 2 to 3 per cent of the cases here longer perform bilateral vasectomy. Various instruments and methods have been employed: the cold punch of Young, the punch of Caulk, the so-called Bumpus punch, the Stearns-McCart sectoscope and many others.

### CARCINOMA

**Etiology**—The etiology of carcinoma of the prostate is unknown. Recently, an endocrine theory has been advanced, generally the basis for this theory is low testosterone. It has been observed that castration of the prostate is often extremely sensitive to the presence of androgens and that testosterone can activate the growth of prostate cancer. In many patients the inactive testosterone neutralization of this hormone brings about retrogression of the cancer cells. Previous infections such as gonorrhea play no role in its development. Cancer of the prostate is rare in persons under fifty and occurs with the greatest frequency between the ages of sixty and seventy. Bumpus in a study of 1000 cases found the average age to be sixty-five years. Almost 50 per cent of cases occurred in patients between the ages of sixty and seventy.

**Pathology**—Roughly, two types of carcinoma are recognized. In one the prostate shows hardly any change from the normal and in the second the prostate is enlarged and nodular and often shows extension of the carcinoma beyond the confines of the gland. In the first form the prostate is normal in size or may be somewhat enlarged. It is of very hard consistency and the surface may appear to be practically normal. This type of prostate is often found in cases in which extensive bone metastases are present, hence were it not for the bone metastases the prostate might be overlooked as the seat of carcinoma. In the second, larger group the prostate is definitely enlarged and the surface is nodular and irregular. The consistency has been variously described, a favorite term being stony hardness. The disease spreads toward the seminal vesicles so that many times the pro-

tions of drugs into the testicle to produce fibrosis are methods that have historical interest only and are of no use today.

**PRELIMINARY PREPARATION**—It is extremely important that each prostatic patient have a complete physical examination before operation or before special examinations are undertaken. As previously mentioned cardiovascular lesions are present in 63 per cent of the patients and it goes without saying that these patients are benefited by close cooperation between the internist, the cardiologist and the urologist. Preliminary study and preoperative preparation of the patient have contributed more to the reduction of the mortality rate than any other single factor. Impaired cardiac function demands rest in bed and some form of digitalis and the fluid intake must be limited. Hypertension is deserving of careful consideration. It is not uncommon to see the

urine and a rapid decompression of the bladder is very apt to have fatal results.

The determination of renal function by means of a blood chemical examination and phenolsulfonephthalein test should be carried out in every case. Renal function will show marked and rapid improvement as treatment progresses.

**CONTROL OF INFECTION**—Infection is best controlled by drainage and by the administration of large quantities of fluid, also by lavage of the bladder. Drainage may be obtained by means of an indwelling catheter or a preliminary suprapubic cystostomy. Undoubtedly in the largest number of patients infection can be controlled with the indwelling catheter although this method has certain limitations in that some patients complain of pain while in others it produces urethral discharge, bleeding, chills and fever. When these complications develop it is better to perform a cystostomy under local anesthesia.

**CHOICE OF ANESTHESIA**—Inhalation anesthesia is being used less frequently and ether should never be used. Ethylene is the inhalation anesthetic of choice. Sacral anesthesia either alone or combined with parascapular anesthesia enjoys a popularity at the present time and when carefully given in the hands of an experienced anesthetist is successful in over 90 per cent of cases. Some surgeons prefer spinal anesthesia. At the present time sodium pentothal is very widely used.

**CHOICE OF OPERATION**—The prostate may be removed in one of three ways: (1) by suprapubic or perineal prostatectomy or by transurethral resection.

*Suprapubic prostatectomy* may be performed in one or two stages and the prostatectomy itself may be performed by division of the internal urethral orifice and enucleation of the prostate with the finger.

*Perineal prostatectomy* following the technique of Young is the most popular method of prostatectomy at the present time.

**Control of hemorrhage** at the time of operation is of the greatest importance because these patients stand loss of blood very poorly. When there is considerable hemorrhage at the time of operation a transfusion should be given. Some surgeons make it a rule to give a blood transfusion before pros-

to take a certain amount of light exercise such as golf or walking. There is no objection to moderate horseback riding. A diet consisting of fresh and cooked vegetables and fresh and stewed fruits is recommended. There is no objection to meat in moderation although the heavier red meats should be used sparingly. Overeating at banquets has often been followed by an attack of acute retention. Alcoholic drinks in moderation are not harmful which is best illustrated in some elderly patients who accustomed to a daily glass of wine with their meals are in a better condition with than without it. The bowels should be kept open by means of suitable diet or with a mild laxative such as cascara compound licorice powder castor oil or enemas.

The patient should be instructed to empty the bladder regularly and especially to void as soon as possible when the desire is present. Hot sitz baths at night give a great deal of local comfort and in some cases reduce the number of voidings during the night. Hot rectal irrigations or the use of the Artz burger tube will be found beneficial.

Massage of the prostate in the early stages may relieve the symptoms. Roentgen ray treatment has no particular value. The injection of drugs into the prostate is a waste of time.

**TREATMENT OF ACUTE COMPLETE RETENTION**—When acute retention of urine develops every attempt to establish spontaneous urination should be tried before catheterization is instituted. The fluid intake should be limited. The application of hot water bags to the perineum and above the pubes often results in spontaneous urination. If this fails hot sitz baths are in order. If there is pain during the attack morphine sulfate hypodermically or belladonna and opium in the form of a rectal suppository are indicated. If these measures fail the use of the catheter becomes imperative. Catheterization should be carried out only under the strictest aseptic precautions. A soft rubber catheter should be used first and if this cannot be passed without trauma a Coude catheter may be tried. At the present time rubber catheters with a right angle beak are obtainable and they can often be passed when the ordinary soft rubber catheter fails. A metal catheter should be used only as a

last resort. The urine should be withdrawn slowly the amount withdrawn depending on the amount in the bladder. It is better to remove it in small quantities even in cases of acute retention.

In cases in which it has been impossible to pass a catheter suprapubic puncture has been carried out. In the hands of a specially qualified surgeon this is a simple procedure and gives a good deal of relief. A catheter may be introduced into the cannula after the trocar is withdrawn and left in place for the purpose of drainage. However it is important to call attention to the fact that this procedure is not necessarily free from danger injury to the intestines followed by fatal peritonitis being a possibility in cases in which there is a low insertion of the peritoneum. On account of the possibility of this danger this method is rarely used today.

**TREATMENT OF CHRONIC INCOMPLETE RETENTION**—Residual urine should be withdrawn daily followed by lavage of the bladder with potassium permanganate 1:4000 or silver nitrate 1:5000. A small quantity of the irrigating fluid may be allowed to remain in the bladder or boric acid solution may be used and argyrol 10 per cent or protargol 1 per cent or nargol 2 per cent injected into the bladder after the irrigation.

**TREATMENT OF CHRONIC COMPLETE RETENTION**—Patients in this group all require operative treatment and unless the retention is relieved must lead a catheter life.

Palliative treatment in this type of case is carried out only during the period of preliminary study. When admitted to the hospital the patient has a suprapubic tumor. The appetite is poor and the tongue is dry. It is exceedingly important that withdrawal of the urine should not be completely done but gradual decompression practiced. Rapid or complete withdrawal of the urine has been followed by severe hemorrhage or by acute ascending infection of the kidney with uremia and death. It is advisable in these cases after the catheter has been passed to fix it in the urethra so as to institute catheter drainage.

**3. Operative Treatment**—Ligation of the iliac artery castration division of the cord or resection of the vas deferens and injec-

tions of drugs into the testicle to produce fibrosis are methods that have historical interest only and are of no use today.

**PRELIMINARY PREPARATION**—It is extremely important that each prostatic patient have a complete physical examination before operation or before special examinations are undertaken. As previously mentioned cardiovascular lesions are present in 63 per cent of the patients and it goes without saying that these patients are benefited by close cooperation between the internist, the cardiologist and the urologist. Preliminary study and preoperative preparation of the patient have contributed more to the reduction of the mortality rate than any other single factor. Impaired cardiac function demands rest in bed and some form of digitalis and the fluid intake must be limited. Hypertension is deserving of careful consideration. It is not uncommon to see the blood pressure fall when infection and fatigue have been corrected. The diabetic patient can withstand operation provided the proper preoperative preparation is instituted. Other complications such as chronic bronchitis, asthma and emphysema should be carefully studied before operation and the condition improved as much as possible. Infections of the mouth should be thoroughly eradicated before surgical treatment is undertaken. Some surgeons believe in the preoperative administration of some sulfa drug to prevent postoperative reactions such as fever.

**IMPAIRED RENAL FUNCTION**—One of the important methods of examination of this group of patients is the estimation of the renal function. When it is not normal it can be greatly improved with treatment. It is important to remember that renal function must be stabilized before operation is undertaken. The importance of fluids in the treatment of impaired renal function cannot be overemphasized. Fluids should be administered by mouth per rectum and if necessary by saline infusion. In some cases it may be necessary to administer as much as 5000 or 6000 cc. of fluid in twenty-four hours. During the administration of large amounts of fluid care must be exercised not to overload and embarrass the heart. It is necessary to decompress the bladder gradually because many of these patients have high residual

urine and a rapid decompression of the bladder is very apt to have fatal results.

The determination of renal function by means of a blood chemical examination and phenol sulfonephthalein test should be carried out in every case. Renal function will show marked and rapid improvement as treatment progresses.

**CONTROL OF INFECTION**—Infection is best controlled by drainage and by the administration of large quantities of fluid also by lavage of the bladder. Drainage may be obtained by means of an indwelling catheter or a preliminary suprapubic cystostomy. Undoubtedly in the largest number of patients infection can be controlled with the indwelling catheter although this method has certain limitations in that some patients complain of pain while in others it produces urethral discharge, bleeding, chills and fever. When these complications develop it is better to perform a cystostomy under local anesthesia.

**CHOICE OF ANESTHESIA**—Inhalation anesthesia is being used less frequently and ether should never be used. Ethylene is the inhalation anesthetic of choice. Sacral anesthesia either alone or combined with paracervical anesthesia enjoys a popularity at the present time and when carefully given in the hands of an experienced anesthetist is successful in over 90 per cent of cases. Some surgeons prefer spinal anesthesia. At the present time sodium pentothal is very widely used.

**CHOICE OF OPERATION**—The prostate may be removed in one of three ways: i. e., by suprapubic or perineal prostatectomy or by transurethral resection.

*Suprapubic prostatectomy* may be performed in one or two stages and the prostatectomy itself may be performed by division of the internal urethral orifice and enucleation of the prostate with the finger.

*Perineal prostatectomy* following the technique of Young is the most popular method of prostatectomy at the present time.

*Control of hemorrhage* at the time of operation is of the greatest importance because these patients stand loss of blood very poorly. When there is considerable hemorrhage at the time of operation a transfusion should be given. Some surgeons make it a rule to give a blood transfusion before pro-

tatectomy is performed Bleeding may be controlled by suture or by the use of a rubber bag or a gauze pack Hemorrhage occasionally occurs two weeks after operation and then is always due to infection

*Complications of surgical prostatectomy* are shock pyelitis fistula dilatation of the stomach bronchitis pneumonia pulmonary embolism and phlebitis Cardiac complications occur less frequently than formerly because of a more careful preoperative study of the patient with heart disease Cerebral thrombosis is rare Coronary occlusion at tacks of angina and myocardial failure are uncommon

Urogenital complications developing after operation are acute epididymitis which occurs in 20 per cent of the cases stricture of the urethra which is more frequent after perineal than after suprapubic prostatectomy and occasionally fistula after either suprapubic or perineal prostatectomy In continence of urine is rare Impotence occurs in a small number of cases and when it does it is generally permanent Stone in the bladder must be considered as a rare complication occurring in about 2 per cent of cases Recurrence following complete removal of the prostate is rare but it does occur It is characterized by the fact that a long interval exists between the removal of the prostate and the development of the symptoms of recurrence

The *mortality* has been variously estimated at from 4 to 9 per cent

*Transurethral Resection*—At the present time transurethral resection is the method most frequently used to relieve prostatic obstruction Its advantages are an exceedingly low mortality rate the short period of postoperative hospitalization and the applicability of this technic to patients who heretofore have been denied relief of symptoms because they were poor surgical risks The mortality varies from 1 to 2 per cent I have performed 238 consecutive resections with 1 death Perfect hemostasis is most important here as in any surgical procedure It is needless to emphasize that complete removal of the obstruction is imperative Fever following resection occurs frequently but is of short duration If it is high or lasts more than a few days one of the sulfa drugs should be given Epididymitis occurs in only

2 to 3 per cent of the cases hence I no longer perform bilateral vasectomy Various instruments and methods have been developed the cold punch of Young the hot punch of Caulk the so called Birsch Bumpus punch the Stearn McCarthy resectoscope and many others

### CARCINOMA

*Etiology*—The etiology of carcinoma of the prostate is unknown Recently however, an endocrine theory has been advanced In general the basis for this theory is as follows It has been observed that cancer of the prostate is often extremely sensitive to the presence of androgens and that this hormone can activate the growth of prostatic cancer In many patients the inactivation or neutralization of this hormone brings about retrogression of the cancer cells Previous infections such as gonorrhea play no role in its development Cancer of the prostate is rare in persons under fifty and occurs with the greatest frequency between the ages of sixty and seventy Bumpus in a study of 1000 cases found the average age to be sixty five years Almost 50 per cent of his cases occurred in patients between the ages of sixty and seventy

*Pathology*—Roughly two types of carcinoma are recognized In one the prostate shows hardly any change from the normal and in the second the prostate is enlarged hard and nodular and often shows extension of the carcinoma beyond the confines of the gland In the first form the prostate is normal in size or may be somewhat enlarged It is of very hard consistency and the cut surface may appear to be practically normal This type of prostate is often found in cases in which extensive bone metastases are present hence were it not for the bone metastases the prostate might be overlooked as the seat of carcinoma In the second and larger group the prostate is definitely enlarged and the surface is nodular and irregular The consistency has been variously described a favorite term being stony hardness The disease spreads toward the seminal vesicles so that many times the prostate and seminal vesicles form one hard nodular mass The carcinoma may spread toward the bony pelvis Because of the spread to the seminal vesicles and the invasion of the

*pelvis*, the prostate has often been described as "frozen in the pelvis." Involvement of the urethra and bladder occurs. Carcinoma may extend around the neck of the bladder in the form of villous growths and in rare instances nodules are seen under the mucous membrane of the trigone. It may spread and involve the rectum and obstruct the bowel movement. Perforation of the rectum is rare but the writer has seen this several times. Carcinoma may extend to the lower end of the ureter producing obstruction with resulting hydronephrosis. Attention may be called to the fact that not all cancers of the prostate show the change in consistency previously described hence when this is absent it can readily be understood why the condition is sometimes overlooked.

Microscopically cancer of the prostate is adenocarcinomatous. In some cases the glandular elements predominate and the tumor is soft. When the fibrous tissue elements predominate the term scirrhous carcinoma is used.

*Point of Origin*—Carcinoma may begin in the posterior lobe or more correctly in the posterior lamellæ or it may take its origin in one or both lobes of a normal prostate. It may also begin in hypertrophied lateral lobes. Carcinoma and hypertrophy may occur at the same time. In some instances because of the presence of benign hypertrophy the carcinoma is overlooked at the time of operation and the diagnosis is not made until sections have been examined microscopically. Young states that 50 per cent of the cases of carcinoma of the prostate seen in his clinic were associated with hypertrophy of both the lateral and the median lobes.

*Metastases*—Carcinoma of the prostate like carcinoma of the breast and thyroid tends to produce bone metastases. In some instances symptoms of bone metastases overshadow the urinary symptoms. The bony structures most frequently involved are those of the pelvis and spine (pelvis 20 per cent spine 20 per cent). Metastasis may occur in any bony structure. The ribs and femur probably next to the pelvis and spine are most frequently involved. The predominating lesion is the production of new bone so-called osteosclerosis although osteoporosis may be present with

osteosclerosis. Sometimes the osteoporosis predominates and this accounts for the spontaneous or so called pathologic fractures. Metastases to the retroperitoneal glands probably occur much earlier than is generally believed because of the difficulty in demonstrating them by palpation and physical examination on account of their deep position. The inguinal and femoral glands as well as the cervical and axillary glands may be the seat of metastatic disease.

*Symptoms*—In the largest number of cases the urinary symptoms predominate in the clinical picture and are characterized by obstruction at the vesical orifice. Urinary symptoms may be of recent origin. Rectal examination reveals the presence of an extensive cancer. In some cases the symptoms of obstruction occur late in the course of the disease. Frequency of urination both day and night associated with difficulty and pain are the symptoms most frequently present. This group of symptoms may be due to the cancer itself or to the associated hypertrophy of the lateral and middle lobes. Complete retention of urine occurs late in the disease although the writer has known this to be the first symptom to bring the patient to the hospital for examination. Gross hematuria may occur but it is rare. Pain in the back over the sacrum or in the renal area and along the course of the sciatic nerve is often present. This may be due to bone metastases or to the pressure of the retroperitoneal extension of the cancer on the nerves. Bilateral sciatica in a man with urinary symptoms should always arouse suspicion of the possibility of carcinoma of the prostate. Spontaneous fracture may be the first symptom presented by the patient. Rectal symptoms such as pain in the rectum constipation and painful or difficult defecation occur late. Proliferation of the carcinoma into the rectum as previously mentioned occurs but is relatively uncommon.

*Diagnosis*—Rectal examination is of the greatest importance in establishing a diagnosis. A careful rectal examination should reveal any changes in the consistency as well as in the contour of the prostate. Increase in the firmness of the gland as well as slight irregularity of the surface should at

can arouse suspicion that the disease is a carcinoma. The presence of small hard nodules is of great value in arriving at a diagnosis. In a well developed case there is no difficulty in making a diagnosis on the basis of a rectal examination. An enlarged hard nodular prostate with extension to and involvement of the seminal vesicles presents no problem in diagnosis.

In the average case cystoscopic examination is of but little value in arriving at the correct diagnosis. It is of value in demonstrating the presence or absence of other lesions of the bladder such as stone, diverticula and so forth. It is also of value in demonstrating the presence of carcinomatous involvement of the neck of the bladder.

Ferguson advises aspiration of the prostate through the perineum as an aid in diagnosis of early carcinoma. Roentgen examination for the presence of bone involvement is of great value especially in cases in which rectal examination is of little value. At times it is difficult to differentiate these bone changes from Paget's disease. Finally in some cases carcinoma is not recognized until after the histologic examination of the removed prostate.

**Differential Diagnosis**—Difficulties may be experienced in relatively young men in whom the consistency of the prostate has changed and by reason of this there is confusion with chronic prostatitis. Stone in the prostate can be demonstrated by the roentgen ray (see section on Diagnosis of Stone in the Prostate). Tuberculosis is rare at the time of life when carcinoma occurs and generally the patient presents other evidences of tuberculosis in the genital or urinary tract.

**Prognosis**—In some cases the growth is very slow. The duration of life after the diagnosis has been made has been estimated at about three and a half years. This depends somewhat on whether the patient presents himself early in the course of the disease or whether metastases are present at the time examination is made.

**Treatment**—Treatment may be considered under four headings: (1) perineal prostatectomy, (2) treatment with radium or roentgen rays, (3) treatment directed toward relief of obstruction and (4) endocrine therapy.

1 *Perineal prostatectomy* with or without the removal of the seminal vesicles has been recommended by Young. In a series of 599 operations for cancer of the prostate life was prolonged in 246 patients for more than five years.

2 *Roentgen Ray and Radium Treatment*—Radium may be applied in one of two ways: by radium emanations inserted into the prostate after perineal exposure or by the introduction of the radium element into the prostate through the perineum with radium needles. The latter method is more simple. Applications of radium through the urethra or through the rectum are rarely used today. There can be no question that radium treatment often causes marked reduction in the size of the carcinoma and no doubt inhibits its growth. Some surgeons prefer the use of deep roentgen rays to radium.

3 *Relief of obstruction* may be obtained by suprapubic cystostomy or transurethral resection. Both procedures have the same objective: namely, to relieve complete retention and to relieve the obstruction at the vesical neck, thereby preventing secondary changes in the ureters and kidneys. Suprapubic cystostomy is rarely employed at the present time. Transurethral removal of the obstruction (electroresection, cautery punch) relieves the obstruction and avoids the necessity of permanent suprapubic catheter drainage. When the obstruction recurs a second resection can be performed. Following the removal of the obstruction by transurethral resection, treatment with radium or deep roentgen rays should be employed as an adjunct.

4 *Endocrine Therapy*—This can be accomplished in two ways: by castration and by the administration of estrogens. There is at present some difference of opinion as to whether these two forms of therapy accomplish the same clinical result. It should be emphasized that both of these methods of therapy do not cure prostatic cancer. The time is still too short to evaluate the end result from these forms of therapy.

## SARCOMA

Sarcoma of the prostate is a rare disease. The literature contains reports of only 132 cases.

**Etiology**—As in sarcoma in other parts of the body the etiology is unknown. In approximately one third of the reported cases sarcoma occurred before the age of ten years but it may occur at any time of life. Adams reported a case in a patient aged eighty-eight.

**Pathology**—Practically every type of sarcoma has been reported. Round and spindle cell rhabdomyosarcoma and leiomyosarcoma occur in about 50 per cent of cases. Among other types may be mentioned angiofibromyxofibrolymphomyxochondrosarcomas. The most frequent sites of metastases are the kidneys, inguinal glands, lungs, liver, pleura and the retroperitoneal glands.

**Symptoms**—In a large number of cases the tumor has reached an extensive growth before the patient consults a physician. Because of the pressure on the bladder, urethra or rectum disturbances of micturition and defecation are often present. Hematuria may occur. Pain along the course of the sciatic nerve may occur in rare instances. Complete retention of urine, edema of the lower extremities and of the scrotum, loss of weight and anemia are later manifestations.

**Course**—As a rule the disease runs a very rapid course. The average duration of life after the onset of symptoms is about one year.

**Diagnosis**—In general the diagnosis is relatively easy to make. Rectal examination shows the presence of a large soft and smooth mass in the prostatic area. In the adult the presence of an enlarged prostate of a peculiarly elastic consistency is highly suggestive. The condition can generally be differentiated from carcinoma which is more nodular and irregular in outline. Tuberculous abscess and stone offer no special diagnostic problems. Great care should be exercised to differentiate between primary sarcoma of the prostate and primary retroperitoneal sarcoma that has extended to the prostate.

**Treatment**—The most favorable results have been obtained with radium and deep roentgen ray therapy. Surgical treatment is indicated only for the relief of obstruction.

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THE MALE EXTERNAL GENITALS  
INJURIES OF THE PENIS AND URETHRA

The location and mobility of the distal aspect of the penis and urethra afford these structures some immunity to direct injuries while the fixed portion which penetrates the triangular ligament and the part immediately in front of this ligament are especially susceptible to both direct and indirect injury because of their anatomical location and immobility. Any portion may receive injuries from sharp penetrating objects both from the outside and from within the urethra.

The flaccid penis may be dislocated from its coverings and displaced under the skin of the scrotum, pubis or thigh. This uncommon injury is thought to be due to a force applied to the extremity. The tear occurs at the sulcus back of the corona. Rupture or so-called fracture of the penis occurs from bending or sudden direct force applied to the organ during erection, causing a tear of the fibrous sheath of the corpora cavernosa. The injury is very painful and the penis becomes edematous which together with hematoma produce a distorted, markedly enlarged structure bent away from the side of the ruptured sheath. Conservative management consisting of elevation of the part, ice packs and later sometimes incision to relieve hematoma is indicated.

Strangulation resulting from the application of a ring or other similar inelastic substances about the penis by insane persons or by others probably unstable mentally for purposes of masturbation is not uncommon in institutional work. There is interference with the blood supply, swelling occurs and the constricting object is often buried deep in the tissues. Gangrene and complete separation of the distal segment may occur if the constriction is not soon relieved. Constrictions of much less severity occur but these persons frequently do not present themselves for treatment until acute urinary retention has resulted which may be too late to save the distal segment intact. The treatment consists of removal of the constricting band.



The removal of the integument of the penis by accidents with machinery in which the clothing has been caught impinging the skin of the penis resulting in its removal in whole or in part is occasionally observed. Some cases of criminal mutilation are encountered in which the penis has been completely stripped of its integument. Plastic operations and skin grafts are usually necessary but the remarkable regenerative capacity of the integument of the penis and scrotum should always be kept in mind.

*Straddle injuries of the bulb and bulbous urethra* are common usually caused by the weight of the falling body when striking a fixed object the force of the fall being applied to the perineum in the region of the bulb. Variable degrees of injury result from contusion of the bulb and urethra to complete maceration of these structures. The extent of the injury usually determines the symptoms but the swelling resulting from a relatively minor injury to the tissues may produce urinary retention and complications.

**Symptoms**—The most common symptoms are perineal pain shock urethral bleeding and difficult or impossible urination. The intraurethral bleeding appears at the external urinary meatus and is not associated with the act of urination except to be aggravated by it as a result of the compressor action of the bulbocavernosus muscle.

**Treatment**—An injury not sufficient to produce intraurethral bleeding or interference with urination should be treated by local application of icebags and should be under careful observation. The hematoma may absorb but may require incision.

External urethrotomy is frequently necessary in order to stop the bleeding relieve urinary retention and remove the hematoma. Urethral dilations must be carried out for many months so as to prevent the development of a stricture.

#### INJURIES OF THE SCROTUM AND TESTICLE

The normal relative mobility of the scrotum and its contents allows these structures some protection against any ordinary type of injury. Gunshot wounds and injuries acquired by sharp objects in motion are

among the notable exceptions resulting in injury to the scrotum and its contents in varying degrees from laceration of the scrotum to marked destruction of the testicular tissue which may necessitate its removal.

**Dislocation of the testicle from its scrotal site** is caused by sudden blows. It is seen in horseback riders and in persons who have had an accident in which a vehicle wheel passed over the body. The testicle is usually driven out under the skin overlying the pubis but may lodge under the skin of the penis or in the groin. Replacement by manipulation or surgical means should be effected immediately otherwise atrophy occurs. A more common condition is the temporary forcing of the testicle into the inguinal canal under the stress of a sudden blow which simulates a true dislocation symptomatically.

The most common injury to the scrotum and testicle results from a fall astride some fixed object and the forcing of these structures against the symphysis pubis. Obviously these injuries vary directly with the directness and extent of the force applied. *Hematocoele* is a common result of injuries caused by crushing direct blows. A firm smooth tender mass is produced that does not transmit light. It usually absorbs but may need to be evacuated surgically. Because of clots aspiration is either difficult or impossible.

**Torsion of the testicle** is rotation of the testicle in either direction with from one to four half turns. The blood supply is interfered with as a result of the twist in the spermatic cord. The condition is more common than supposed as it is frequently mistaken for epididymitis. A normal testicle probably could not be so rotated which implies that some anatomical abnormality is present. The condition occurs in undescended testes in about half the cases. The following anomalies have been given as possible causes: the abnormal attachment of the common mesentery and vessels to the lower pole of the testicle and globus minor; the elongation of the globus minor; a capacious tunica vaginalis and the incomplete attachment of the epididymis to the scrotum. Sudden muscular effort is frequently the exciting cause but the condition has occurred during sleep. Thrombosis of the

vessels below the twist and varying degrees of necrosis of the testicle depending on the length of time since the onset are present. The symptoms include sudden severe pain in the testicle associated with shock, nausea and sometimes vomiting. Examination early reveals a painful swollen testicle the difference between the testicle and epididymis by palpation is soon lost and the scrotal tissue becomes edematous. Later the pain subsides but the testis remains tender and swollen. There is fever and leukocytosis. In an undescended testis the condition simulates strangulated hernia while in the descended testis excepting for its onset it suggests epididymitis.

**Treatment**—Early recognition and surgical relief are successful and imperative since later treatment either conservative or surgical cannot prevent atrophy. It has been suggested that the anomaly which makes the condition possible is bilateral hence the other testicle should be more closely fixed to the bottom of the scrotum as a prophylactic measure.

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## STRICTURE OF THE URETHRA

Stricture of the urethra is an organic narrowing of this structure which is usually caused by scar tissue.

**Congenital stricture** is due either to a developmental defect or to an early unrecognized infection which causes stenosis of the meatus at the peno-scrotal junction or at the bulbomembranous junction. It is usually recognized by frequency and difficulty of urination sometimes associated with dribbling. Patients with chronic emuresis should be examined for this defect. Mental stricture is apparent on inspection but the deeper ones are diagnosed only by instrumentation. Mental strictures must be cut while the deeper ones may respond to dilation.

**Traumatic stricture** is the result of scar tissue developed following injuries of the submucosal tissues. In the anterior urethra

it commonly results from improper instrumentation or a straddle injury of the bulbous portion while in the posterior urethra fracture of the bony pelvis with urethral injury is the chief cause. Traumatic stricture develops within a few weeks or months following injury, whereas inflammatory stricture requires a much longer time for its presence to become apparent.

**Inflammatory strictures** are almost all of gonococcal origin, chancreoid and chancre about the meatus and tuberculosis being exceptions. The severity of the gonococcal infection rather than its chronicity produces stricture. Careful gentle treatment of gonorrhea prevents this complication while injudicious instrumentation and the use of strong antiseptics intensify the infection and tend to produce stricture.

**Pathology**—A stricture is essentially a fibrous scar in the urethral wall usually started in the submucosa about the urethral glands and lacunae. Contraction of the scar makes further narrowing up to the point of almost complete occlusion at times. As the glands are on the floor and lateral walls the scar tissue predominates there the lumen being toward the roof. A stricture may be a single band or may cover an area of several square centimeters. Multiple strictures may be present the lumens of which are progressively narrower as the posterior urethra is approached. Ulceration of the mucosa often occurs both in front and behind a structured area which accounts for the presence of coarse leaviness in the first voided urine. Perurethral abscess and urinary extravasation sometimes result. Prostatitis and seminal vesiculitis usually supervene and spontaneous recurrent epilythymitis is not unusual. The amount of residual infection is usually not great but hypertrophy or dilatation of the bladder results followed by dilatation and ascending infection of the upper urinary tract in longstanding severe cases.

The symptoms are those of chronic urethritis i. e. a gleet discharge and later frequency and difficulty of urination associated with dribbling and sometimes incontinence. Acute urinary retention may occur as a result of local congestion brought on by exposure to wet and cold, voluntary retention of urine or instrumentation.

The diagnosis is not difficult to make after obstructive symptoms appear. Too often the necessary examination is not made when chronic discharge alone is present. The use of bulbous bougies and sounds to calibrate the urethra establishes the diagnosis.

Prophylactic treatment consists of careful gentle treatment of the gonorrhea. Active treatment is preferably by dilation. In certain cases of tough stricture of the shaft of the penis internal urethrotomy is required while stricture of the bulb that does not admit a filiform bougie must be opened by external urethrotomy. Whether treatment is primarily by dilation or by cutting dilating instrumentation must be continued at increasing intervals for months or years until all tendency of recontraction has disappeared. Infections of the genital and upper urinary tract must be appropriately managed.

The course taken by the periurethral infection depends on the virulence of the bacteria as well as on the tissue resistance of the host. If the local periurethral tissues maintain control the infection remains localized and a periurethral abscess is formed; however if local conditions are not favorable for localization the infection spreads as cellulitis. The course of the cellulitis is determined by the fascial planes of the pelvis and penis (Fig. 666).

Superficial infiltration results from erosion proximal to a stricture usually of the bulbous portion which allows infection to become periurethral into the superficial ti-

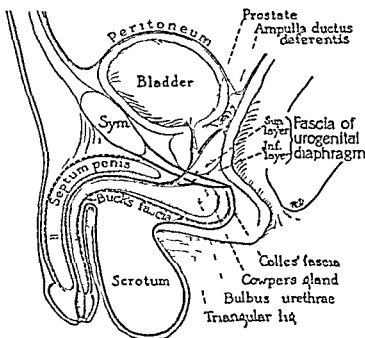


Fig. 666.—Showing the fascial planes which determine the course of phlegmonous infiltration.

## PHLEGMONOUS INFILTRATION

### (Urinary Extravasation)

*Phlegmonous infiltration* formerly called urinary extravasation is a condition in which infection extends beyond the urinary channel at a point made vulnerable by ulceration. This point is usually just proximal to a structured area of the anterior portion of the urethra. It has been presumed but never proved that urine accompanies the infection. Since this complication often occurs in the presence of large caliber (18 to 20 F.) strictures the directing force could not be adequate here to force urine into the periurethral tissues.

The course of the phlegmon is prevented from going back of the triangular ligament by its ventral attachment to Colles' fascia. The latter directs the effusion forward into the superficial tissues of the scrotum, penis and abdominal wall. Infiltration starting distal to the posterior attachments of Buck's fascia is confined to superficial tissues of the penis by this fascia. Both types of superficial infiltration require external urethrotomy and multiple incisions to effect drainage of the tissues involved.

Deep urinary extravasation results from breaks back of the triangular ligament. By far the most common cause is urethral injury associated with a fractured pelvis.

Urine is forced into the periprostatic tissues, it soon becomes perivesical and finally may extend up on the abdominal wall separating the peritoneum from the transversalis fascia. Usually the diagnosis is obvious when the patient is first seen, but with peritoneal irritation and its associated protective muscular rigidity, intra abdominal lesions may be suspected.

The management is always surgical and includes the providing of suprapubic drainage of the bladder and perivesical tissues, also realignment of the ruptured and tortuous urethra and the maintaining of the abutment with a firm inlying urethral catheter.

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### TUMORS OF THE TESTICLE

Tumors of the testicles are not common. They occur once in every 2000 male admissions to the hospitals and represent 0.57 per cent of all malignant tumors in men being relatively more common in the undescended than in the normally placed organ.

**Etiology.**—The tumors occur in infants, boys and men, the greatest incidence being between the ages of twenty and fifty, the tumors very uncommonly appearing before puberty. Trauma as a factor, is open to various interpretations. About 50 per cent of the histories cite trauma of some sort, but the causal relationship still remains to be proved. The chronic irritation and direct trauma to which an incompletely descended testicle is subjected may be a factor. The frequency of epididymitis and the relative rarity of testicular tumors probably indicate no causal relationship, however, some tumors are first apparent following such an infection. Himmán states that "it is doubtful whether single injuries to a normally placed organ do more than call attention or act as a stimulus to an already existing growth."

**Pathology.**—Benign tumors of the testicle are very rare. Fibroma of the tunica albuginea and true leiomyoma have been observed. As a rule, tumors of the testicle are malignant, being among the most malignant of all neoplasms.

The older literature abounds with names for different cell arrangements. This confusion was somewhat

cleared when, with better histologic methods and careful study of serial sections, it was discovered that the majority of these tumors have a tridermal constitution and are in fact teratomas. There is still lack of unanimity in their classification, some authors believing that practically all are teratomas, while others hold that there is a second group of pure tumors originating from the cells of the seminiferous tubules.

It is well to recognize two main groups: (1) mixed tumors (teratomas) and (2) pure cell types (seminomas).

Mixed tumors are derived from all three primary germinal layers. The derivatives from all three layers are frequently found, but owing to overgrowth of one cell type, one germinal layer derivative may be missing or really overlooked in the section. The most common type of teratoma has a tridermal cell arrangement in no definite form and bears little or no resemblance to a full organ, while the more highly differentiated dermoids (rare) may contain teeth, hair, bones and other tissues recognized as being, from almost every organ of the body. Any one of the three types of cells become malignant and about half of all testicular tumors are teratogenous carcinomas. Chorionic carcinoma is a rare type of teratogenous tumor that behaves like as elsewhere. Pure cell types of tumor, the seminoma of Cleverley (known by Fung as *testicular lymphoma* or *monodermal teratomatous derivatives*) are derived from the epithelium of the seminiferous tubules and represent about 40 per cent of all testicular tumors.

Sarcoma, formerly considered the most common tumor of the testicle, undoubtedly is the rarest, if as such it exists at all.

Metastases from tumors of the testicle occur primarily by way of the lymphatics. The lymph vessels follow the course of the spermatic vessels and drain into four to six lumbar retroperitoneal lymph nodes alongside the vena cava and aorta, respectively. Secondary nodes are in the pelvis along the iliac vessels. The inguinal nodes are not invaded unless the scrotum is involved or unless there is a back up from the primarily involved lumbar region. Blood vessel dissemination does occur in some cases, especially in chorionic carcinoma.

**Symptoms.**—There is no characteristic clinical picture. Usually there is first noticed a painless swelling of the testicle, without tenderness. There is sometimes a period of quiescence and then, owing to trauma or for no apparent reason, the growth becomes rapid. As a rule, the course is rapid and without early and adequate management the condition is fatal within a year. Symptoms and findings of lymphatic involvement before the testicular tumor is apparent are not infrequently observed, especially in teratomas. Symptomatic hydrocele is common.

The diagnosis is principally a matter of exclusion. The growth may be slow or very rapid and the tumor may be small or very large and complicated by hydrocele. The

shape of the testicle is usually maintained until later when nodulations may appear. Syphilis (tertiary), tuberculosis, non-specific epididymitis, hydrocele and hematocele may afford problems in diagnosis.

Zondek has demonstrated that in most cases of testicular tumor a gonadotropic substance is liberated in the urine. This substance is now known to be present in diagnostic amounts in approximately 85 per cent of testicular tumors. Dean states that this test cannot be used to determine the histological type of tumor because there is no close correlation between the hormone level and the type. The test is of definite value in making a prognosis because in general those with a high level die sooner than those with a low level. It has since been proved that with other conditions a similar hormone may be liberated and that irradiation of a testicular tumor temporarily affects the liberation of this hormone. Nevertheless, testing for this hormone is a valuable adjunct in diagnosis and after operation it may anticipate the prognosis.

Procrastination due to incompleteness of positive diagnostic findings may waste valuable time when early surgical treatment might effect a cure.

**Treatment.**—The superficial location of the normally placed and inguinal testes would seem to afford early recognition of such lesions. That only 15 per cent of cures are obtained by simple castration is ample proof of the fact that extension beyond the testicle has usually resulted before the diagnosis is made.

A radical operation consisting of removal of the testicle, the cord and the retroperitoneal lymph vessels and nodes *en masse* while it is a much more hazardous surgical procedure (10 per cent surgical mortality) than simple castration has resulted in cures in 30 per cent of suitable cases according to Himmans' statistics. When there is palpable evidence of glandular metastases the tumor is inoperable by either simple or radical methods. In these cases radium picks and roentgen therapy may prevent the progress and prolong life. The results obtained with preoperative irradiation have not been convincing. After either type of surgical treatment a thorough course of radium or roentgen therapy is indicated.

Coley's fluid while not generally conceded to be of value here has been reported as being of value as an adjunct in the diminution and retardation of the growth and amelioration of the symptoms.

Success in the management of these tumors obviously depends on early recognition and removal of the tumor bearing area followed by thorough irradiation. Obsecure chronic testicular enlargements should not receive palliative management over unnecessarily long periods of time; surgical exploration is indicated.

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#### SPERMATOCELE

*Spermatoceles* are retention cysts originating in the vasa efferentia, the tubules connecting the epididymis to the testicle. Whether these cysts arise from complete or from aberrant tubules with blind endings and are not connected with the epididymis is an unsettled academic question.

Of several causative factors considered, the one most commonly held is that a cyst results from obstruction of one of the vasa efferentia with subsequent dilatation. Likewise dilatation of aberrant vasa efferentia with blind endings must also be included. They occur in persons twenty-five to fifty years of age; small ones are often found in older men. They vary in size from non-clinical per-sized masses to cystic masses containing several ounces. They are usually single but may be multiple and the larger ones may be multilocular owing to pericystic adhesions and bands. They are mostly extravaginal but may be intravaginal and may simulate hydrocele. Rupture of an intravaginal cyst explains the occasional findings of spermatozoa in hydrocele fluid. They contain a milky, alkaline or neutral fluid which contains no albumin and has a low specific gravity (1.002 to 1.006). Microscopically there are varying numbers

of active or inactive spermatozoa depending on the cystic connection with an active tubule.

Spermatocele is commonly found on routine physical examination unknown to the bearer but it may have been noticed as a growing mass at the top of the testicle which is usually pushed downward and forward. Owing to the size and weight of the cyst there may be a dragging sensation in the testicle and spermatic cord.

On palpation there is a rounded heart-shaped fluctuating mass connected with the upper pole of the testicle at its union with the epididymis. With a large soft cyst these relations may not be apparent. A spermatocele usually transilluminates and the diagnosis can be made with certainty only by aspiration. The fluid obtained usually distinguishes it from hydrocele but both lesions are not uncommonly found together. Neoplasms and tuberculous epididymitis must always be kept in mind as possibilities.

**Treatment.**—A small or moderate sized spermatocele usually requires no treatment. A large cyst producing local symptoms or mechanical interference should be removed surgically. It is technically possible sometimes to free the cyst from its pedicle and resect it again it may be necessary to open the cyst and remove the lining completely. This may be done by cauterization. When multiple small cysts are found together with a large cyst a partial upper pole epididymectomy is indicated. Partial epididymectomies may be necessary also when dense adhesions are encountered. Injection treatment of spermatocele is valueless.

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## CRYPTORCHIDISM

### (Undescended Testicle)

**Incidence.**—Imperfect descent of the testicle during the first few months of extra-uterine life is common (14 per cent according to some statistics). In many cases however the descent is spontaneous during the first year. Undescended testicle is variously estimated to occur in from 0.1 to 0.2 per cent of males. Neither side appears more

susceptible than the other but bilateral involvement is rare.

The descent of the testicle may be stopped at any stage. Thus there may be the following types:

1 Abdominal type (does not enter the inguinal canal)

2 Inguinal type (arrested in the inguinal canal)

3 Subinguinal type (arrested just below the external ring)

Rarely the testicle may be movable and may change from one type to another. The testicle may migrate to the pelvis, abdominal wall, penis or perineum or even to the other side of the scrotal sac (inversion of the testicle).

The commonly mentioned theoretical causes of this condition are shortness of the blood supply or of the vas deferens, an abnormally large testicle or epididymis, peritoneal adhesions, deficiency or absence of scrotal attachments of the gubernaculum and an improperly developed inguinal canal.

There are no symptoms especially referable to this condition and the diagnosis is apparent with the finding of the empty scrotal sac, the rare conditions of anorchism and ectopia being kept in mind. Acute epididymitis in such an organ however may be difficult to differentiate from strangulated hernia or torsion of the cord. Immediate operation is indicated regardless of the type of lesion.

An undescended testicle of any type is unfavorably affected by its abnormal position. It has been shown experimentally that because the temperature of the abdominal wall and its cavity is higher than that of the scrotum an undescended testicle is usually sterile. Being relatively immobile it is more subject to trauma and varying degrees of atrophy from anemia and its increased susceptibility to neoplasms and torsion has been definitely established. The inguinal and subinguinal types are frequently associated with hernia.

**Treatment.**—An undescended testicle is seriously affected if allowed to remain as such and operation is therefore indicated.

Spontaneous descent rarely occurs after the first six years of life. It is generally agreed that in cases of undescended testicle or epididymis should be performed between the ages of six and nine years when the struc-

tures are not too small cooperation of the patient may be had and the dangers of serious degenerative changes have not yet occurred. No operation should be performed for an intra-abdominal testis (Fraser).

Orchidectomy is indicated only if a neoplasm is present or if complete destruction from trauma or infection has occurred.

**Operative Treatment**—Bevan has shown that shortness of the vascular supply and not shortness of the vas deferens prevents the placing of the testicle into the scrotum. Lengthening the blood supply consists of dissecting away the fibrous attachments which retain the vessels in their tortuous position producing straight vessels from the internal ring to the testicle. Further length may be obtained by freeing the vessels from the lateral and posterior wall of the peritoneum. Cutting the main blood supply and depending on the deferential artery which follows the vas deferens for the blood supply was frequently practiced formerly but atrophy of the testicle resulted too frequently to warrant the procedure.

Anchoring the testicle to the bottom of the scrotum and other modifications of the procedure are not deemed necessary.

An associated hernia should be dealt with according to its type; however, a standard hernia closure should be made without the presence of this complication.

Many types of operations have been presented and reported as successful and any one of them which includes the fundamental requisites is certain to be successful in the great majority of cases.

**Medical Management**—There are numerous reports in the literature dealing with the value of gonadotropic substances in producing spontaneous descent of undescended testicles. These reports are most conflicting and confusing. While descent does occur sometimes under this management many valued opinions indicate that this happens only when the testicles would have descended without any management. The presence of firm adhesions encountered at operation in properly selected cases as regards the age of the patient and the local position of the testicle tends to confirm the correctness of this opinion. Some reports have been made of necrosis of the testicle following hormone treatment.

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## VARICOCELE

Varicocele is a condition characterized by dilatation, elongation and tortuosity of the spermatic veins. In advanced cases the deferential and cremasteric veins are sometimes involved.

Idiopathic varicocele is a common condition in young men. The left side is most commonly affected, presumably because of the poorer venous flow resulting from the right angle insertion of the left spermatic vein into the renal vein. Bilateral varicocele is rare and right-sided involvement alone rarely, if ever occurs.

**Symptoms**—Varicocele usually produces no symptoms unless attention is directed toward the lesion in a neurotic person. A dragging pain along the cord and in the testis does occur as well as certain obscure low back pains. Mental symptoms of varying degree may appear depending on the mental stability of the patient.

**Diagnosis**—Examination reveals a low hanging scrotum containing an irregular elongated mass above the testicle. The testicle is frequently soft and small. When the patient is lying down the mass may completely disappear.

**Treatment**—In the great majority of cases a varicocele requires no treatment. The demands of industry for operations before men will be employed have increased the number of operations needlessly. Under no circumstances should a highly neurotic person be subjected to operation unless there is a well advanced lesion. A snug suspension often suffices even in apparently well advanced cases. Mental treatment is often more valuable than an operation and reassurance of the benign nature of the condition should always be given regardless of the

local management. Operative management should consist of open operation and not subcutaneous ligation. The enlarged veins should be carefully dissected away from the remainder of the cord, starting 1 inch above the testicle and extending upward to just below the external ring. The veins are thoroughly ligated at each end and the intervening strip is removed by cutting. The venous stumps are brought together and held by ligature for support of the testicle. Atro-

phy of the testicle may result, and secondary hydrocele occurs more commonly. To obviate this second complication, a regular hydrocele operation of the tunica vaginalis has been carried out at the time the veins were removed.

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on voiding and usually a slight leukorrhea. Since these sensations are not uncommon they may cause no apprehension and may disappear within four or five days. In severe cases these disturbances are more marked. It is rare however for a woman to be incapacitated by acute gonorrhea of the external genitalia.

Chronic gonorrhea of these organs also may be symptomless unless an abscess or cyst forms in Skene's or Bartholin's glands or the leukorrhea or burning at urination becomes disturbing.

**Diagnosis**—The diagnosis is made by finding the lesions and by demonstrating the gonococcus in the secretions by stain or culture. In acute cases this is usually easy, in chronic infections specificity may be difficult to establish. The discharge may contain many secondary invaders (colon bacillus, streptococcus, and staphylococcus) that the gonococcus may be submerged. Conclusions must then be based on the clinical picture as a whole.

**Treatment**—During the acute stage it is unwise to try any local measures but cleanliness. Efforts to treat the red swollen urethra will almost surely cause cystitis and local treatment of the acutely infected cervix is apt to produce salpingitis and peritonitis. Local cleanliness is necessary and accomplished by soap and water to the external genitalia or external perineal irrigations (not vaginal douches) of potassium permanganate solution 1:6000 two or three times daily.

During the acute stage hygienic measures must be employed to protect other members of the household and the patient herself especially her eyes and to prevent the infection from spreading to the internal genitourinary apparatus and peritoneum. Fortunately since chemotherapy has been introduced efficient curative therapy is also possible during the acute phase.

For hygienic purposes the patient is isolated as far as lavatory and bathroom facilities are concerned. Little girls are scrupulously prevented from using any bathroom facilities that are used by an infected person. To protect the patient's eyes from infection the hands must be kept away from her face. Coitus is forbidden.

Medical therapy consists of rest in bed

forcing water (3000 cc daily) and chemotherapy. Rest in bed is not always essential but will shorten the disease and may prevent its further extension. Gonorrhea is susceptible to the sulfonamides and they are used in ordinary doses (sulfathiazole 4 to 6 Gm daily) with usual precautions. Penicillin is also apparently effective against the gonococcus but is difficult to use outside of a hospital. Sulfonamides should be continued at least a week or ten days. By this time the local infection should be either eliminated or well under control. Smears and cultures are taken from the cervix and urethra at the end of this treatment and must be repeated at monthly intervals for two or three months.

In the chronic stage chemotherapy is not so effective and measures such as douches and local heat are merely palliative. It may be impossible to find the gonococcus in old lesions in Bartholin's glands, the cervix or Skene's glands but the frequency of exacerbations and recurrent symptoms indicate the persistence of infection whether due to the gonococcus or some other secondary invader. In these closed lesions without adequate external drainage the disease can best be eliminated by excision of the infected Bartholin's gland, excision or cauterization and destruction of the perineal gland and cauterization of the cervix. This cauterization must be thorough, opening up and destroying all infected glands. The cauterized cervix or urethra should be dressed every week, the exposed tissues being saturated with some strong antiseptic such as tincture of iodine, 20 per cent silver nitrate or 20 per cent mercurochrome solution. It is only by such thorough measures that the deep foci of gonorrhea may at times be eliminated.

**The Internal Genitalia—Pathology**—In acute gonorrheal salpingitis the entire tube becomes red and swollen and exudes pus which contains gonococci. As the acute process subsides the fimbria usually closes and at various points the tube presents nodular thickening. It adheres to surrounding structures. If the secretions within the closed tube increase the tube distends, its walls become thick and there develops a hard sensitive convoluted mass—a pyosalpinx. In old cases the fluid may be watery—a hydrosalpinx. Both tubes are usually involved. Thus gonorrhea often results in

some permanent damage, such as closed tubes nodular thickening adhesions pyosalpinx or hydrosalpinx

The usual ovarian lesion is perioophoritis a superficial infection of the ovarian capsule and may produce permanent thickening of the tunica albuginea and adhesions thus interfering with normal ovulation. The gonococcus rarely invades the ovarian stroma unless it finds a portal of entry in a fresh corpus luteum or graafian follicle. This may cause an ovarian or tubo-ovarian abscess. Salpingitis is usually accompanied by pelvic peritonitis.

*Clinical Characteristics*—Gonorrheal salpingitis if treated intelligently should rarely be fatal. Death may occur from peritonitis a neglected pelvic abscess intestinal obstruction or an operative accident.

The usual symptoms are pain in the pelvis sacral brachache leukorrhea dysuria menorrhagia dysmenorrhea malaise and occasionally nausea and vomiting. Usually fever slight elevation of the pulse suprapubic tenderness and on bimanual palpation acute tenderness in the pelvis are noted. In acute cases there are usually no masses but they may be found later.

The course is usually benign. Within ten days the infection usually subsides and localizes the treatment being rest in bed in Fowler's position douches of a gallon of hot permanganate solution (1:6000 twice daily) icecaps to the abdomen chemotherapy and sedatives as needed.

*After recovery from the acute attack* the subsequent course varies depending upon the persistence of the remaining foci of infection in the patient or reinfection from external sources. Although symptomatically well the patient may harbor a chronic infection in the external genitalia or the fallopian tubes which may cause exacerbations at any time. Such exacerbations are particularly liable to develop after a menstrual period. Hence for several months after recovery from an attack of acute gonorrhea chemotherapy should be used for a few days after every menstrual period prophylactically.

The damage to the tubes and ovaries is cumulative depending upon the number of reinfections or exacerbations. In neglected cases, the tubes are hopelessly destroyed

and at times also the ovaries. Pelvic abscess with secondary invaders and peritonitis may develop often with fatal results.

*Treatment*—The treatment of acute salpingitis has been outlined—rest in bed forcing water icebags to the lower part of the abdomen hot (gallon) douches sedatives and chemotherapy. Almost invariably resolution is prompt. In reinfections or subsequent recurrences the treatment is similar. Usually acute exacerbations will quiet down but as the tubal damage increases masses persist even after the symptoms disappear. In general in recurrent salpingitis the safest therapy is surgical—bilateral salpingectomy. Healthy structures are not removed. In neglected cases in which the ovaries have been practically destroyed oophorectomy and hysterectomy may be necessary. Surgical treatment is best postponed till the acute exacerbations have subsided.

*Differential Diagnosis*—It is most important to differentiate acute salpingitis from acute appendicitis. Acute appendicitis demands immediate operation. Acute salpingitis rarely does. The proper diagnosis is of fundamental importance.

*Salpingitis* is indicated by a history of the primary infection dysuria vaginal burning leukorrhea and perhaps menstrual irregularity. The tenderness may also be more diffuse and suprapubic especially in the cul-de-sac of Douglas and the pelvic floor. The outlet is marred and the presence of gonorrhea of the external genitalia is strong presumptive evidence.

*Appendicitis* is indicated by gastrointestinal disturbance usually nausea and vomiting generalized abdominal pain and later localized pain at McBurney's point. Muscle spasm and tenderness are usually more sharply localized in appendicitis and rebound tenderness referred to McBurney's point suggests appendicitis.

In both salpingitis and appendicitis the acute attack may start during menstruation. In both leukocytosis with an increase in the polymorphonuclear leukocytes is accompanied by fever and acceleration of the pulse. A mass is rarely felt in either case during the early stages. If appendicitis can not be excluded the abdomen should be opened rather than allow an appendix to rupture.

It is sometimes difficult to distinguish acute salpingitis from extrauterine pregnancies. Ovarian cyst with a twisted pedicle or a variety of acute pelvic conditions. In the chronic stage pyosalpinx may be confused with an ovarian tumor corpus luteum cyst or endometriosis.

**Gonorrhea in Children**—In girls before puberty gonorrheal infections are usually limited to the vagina and cervix salpingitis peritonitis and metastatic lesions are rare. In the vagina and cervix the infection invades not only the mucosa but also the deep submucosal tissues including probably also the cervical canal and glands. The reason for this peculiar localization is the thinness of the vaginal epithelium before puberty and its low resistance to any infection. The child's vaginal epithelium attains full development at puberty due to stimulation by the growth hormone estrin. This same sexual development can be brought about precociously by the administration of estrogenic substances. In rodents this vaginal response to estrin is used as a test for the presence of estrogenic substances.

This physiological fact is also the basis of the modern treatment of gonococcal vaginitis in children. It was first used by Lewis in 1913. If in children with gonococcal vaginitis one changes the vaginal epithelium to the thick mature resistant type the infection usually disappears promptly without any additional therapy. Estrogens are used daily in the form of vaginal suppositories which contain stilbestrol aminotin or some other similar estrogenic material. By vaginal smears one follows the progress of the vaginal development until the smear finally shows only angular cornified epithelial cells without any immature cells pus cells or gonococci. Cultures are also advisable. This change is usually complete in ten to fourteen days. To favor the permanent elimination of gonococci estrogenic vaginal suppositories are given for a week or ten days longer perhaps less frequently. Also follow up studies are repeated at intervals of one month to be sure that the child is well.

In the majority of cases this results in permanent cure. But the gonococcus is a persistent organism and recurrences or reinfections occur in perhaps 10 or 15 per cent. In these cases it is wise to inspect the vagina

with a Kelly tubular cystoscope. Occasionally foreign bodies are found or foci that should be treated locally by the application of mercurochrome acriflavine or silver nitrate.

*Sulfonamides* have also been used usually with good results. But here too recurrences have been noted and local therapy may be necessary. An antiseptic solution can be applied with a medicine dropper which is inserted into the vagina.

## TUBERCULOSIS

Until thirty years ago pelvic tuberculosis was thought to be rare. Now it is known that perhaps 7 per cent of all pelvic infections that require operation are tuberculous.

**Pathology**—This phase has been studied carefully by Hegar (1886) Schlumpert (1914) Greenberg (1921) and others. In many fundamental particulars it differs strikingly from gonorrhea.

Pelvic tuberculosis is a local manifestation of a systemic disease the primary focus of which may be the lung the intestinal tract or the lymph glands in the neck or mediastinum. In women the reproductive organs rank fourth in frequency the lungs intestinal tract and peritoneum being more often involved.

Tuberculosis and gonorrhea differ as to the localization of the pelvic lesions. In gonorrhea the external genitals the urethra Skene's glands Bartholin's glands the vagina and cervix are always involved to a greater or less extent. In tuberculosis however these organs are hardly ever involved as the writer pointed out in 1921. Tuberculosis attacks the fallopian tubes in almost every case the endometrium in three fourths and the ovaries in one third of the cases. Tuberculosis is therefore a disease of the internal reproductive organs.

Tuberculosis is usually a progressive disease and is often more destructive than gonorrhea. Pregnancy is rare after tuberculous salpingitis and is usually disastrous. Gonorrhea starts on the mucous membrane affecting the deeper structures secondarily. Tuberculosis being metastatic affects every part of the organ causing multiple tubercles which coalesce erode and form hard abscesses of various sizes.

General peritonitis occurs more commonly with tuberculosis than with gonorrhea. Whether independently or not, tuberculous peritonitis and tuberculous salpingitis occur with almost the same frequency and very often are coexistent. The peritoneal symptoms of tuberculous salpingitis are often the outstanding characteristics of the disease.

**Clinical Picture**—For these reasons tuberculous pelvic infections are potentially more serious than gonorrheal infections but in many cases the course is relatively mild with practically no physical incapacity and with quiet resolution. Laparotomy later discloses healed tubercles scattered over the surface of the reproductive organs and peritoneum. In such instances the disturbance was probably a superficial tuberculous peritonitis without salpingitis or endometritis. In other instances persistent leukorrhea may be the only symptom and curettage may reveal unsuspected tuberculous endometritis.

The onset is usually vague, a common antecedent being a miscarriage or normal pregnancy. It occurs most frequently in the period of sexual activity. The symptoms are usually those of a chronic pelvic infection and the clinical picture is rarely characteristic enough to suggest tuberculosis. In some instances the diagnosis cannot be made at operation, microscopic examination being required. At times a diagnosis of malaria or typhoid fever has been made.

The constitutional symptoms are marked chiefly by their persistence and indefiniteness—malaise, anorexia, recurring fever in digestion and loss of weight. The local symptoms may suggest gonorrhea, ovarian tumor, malignancy or appendicitis but rarely tuberculosis. The resemblance at any time depends on the stage of the disease.

During the acute febrile stage when the pelvic organs are edematous and swollen the peritoneum is covered with milium tubercles and free fluid is present the diagnosis may be fairly easy if the pelvic masses are palpable. Certain medical conditions which might produce a similar abdominal picture must be ruled out. If pelvic pain, menstrual disturbances, leukorrhea, sterility and pelvic masses are present and if gonorrhea can be eliminated the diagnosis of tuberculosis may be ventured. If the patient is a virgin who has had other tuberculous le-

sions the likelihood of pelvic tuberculosis is increased.

After absorption of the free fluid and subsidence of fever the only residuum may be adhesions, healed tubercles, closed tubes and dormant lesions in the pelvic organs and lymph glands. During this afebrile state, preoperative recognition of the condition is practically impossible. The diagnosis is often made when the abdomen is opened for some unrelated indication. It is during this dormant and afebrile stage that the best surgical results are obtained.

The third or massive stage is characterized by the presence of pelvic and abdominal masses and dense adhesions and is the most serious form of the disease. The intestine, omentum, bladder, rectum and reproductive organ are inextricably tied up in inflammatory masses. Cold abscesses developed from broken down caseating tubercles form masses between loops of intestine and may produce intestinal fistulas. Caseating glands add to the confusing picture. Free fluid may be present.

In this stage the patient is really sick. Loss in weight, digestive disturbances, fever, nausea, vomiting, obstinate constipation, abdominal pain and distention are common. The patient may feel an abdominal mass. Menstrual disturbances, leukorrhea, amenorrhea and pelvic pain are common.

Under these circumstances every conceivable diagnosis is possible. The history or the finding of healed tuberculosis elsewhere may suggest the diagnosis. Diagnoses have included all forms of abdominal and pelvic pathologic conditions, especially carcinoma of the ovary and pelvic tumors with infection.

**Treatment**—In this stage the operative treatment is unsatisfactory and may be followed by serious postoperative sequelae—peritonitis, obstruction, hemorrhage and fistulas. Because of the raw areas and oozing surfaces the operator is often tempted to institute drainage but experience has shown that abdominal drainage invites rather than prevents trouble.

**Sanatorium treatment** and prolonged medical care have a definite place in the treatment of pelvic tuberculosis. In general surgical intervention is advisable only when the disease is limited to the pelvis or abdo-

men Fever is often an indication that the tuberculous process is active and operation may eliminate it generally. Consequently the best surgical results are obtained when the process is inactive. In some cases the diagnosis is in doubt and delay inadvisable. Hence many operations are necessarily performed under the most unfavorable circumstances.

In general three fourths of the patients at Johns Hopkins Hospital have improved very satisfactorily after surgical removal of tuberculous pelvic organs. After the first year the results are better because tuberculous dissemination usually develops within that time if it is to appear at all. The chief advantage of surgical treatment is that it shortens hospitalization in every case; however prolonged medical supervision is essential.

#### PUERPERAL INFECTIONS

Only a brief resume of the surgical aspects of puerperal infections will be given here.

The story of puerperal fever goes back to the beginning of medicine. Although a tremendous morbidity and mortality had stigmatized maternity hospitals for centuries and epidemics of virulent childbirth sepsis had occurred regularly, the cause of the fever was entirely a mystery until Oliver Wendell Holmes (1842) and Semmelweis (1847) proved that it was a wound contamination and that the causative agent was almost invariably transmitted by the doctor or midwife. They knew nothing about bacteria but their pathologic concept was as sound as it was revolutionary. Their ideas were not acceptable to their professional contemporaries and puerperal sepsis continued its ravages.

Since that time the sciences of bacteriology and pathology have yielded compelling proof of the theories of Holmes and Semmelweis. Nevertheless the danger of puerperal infection still makes normal childbirth as hazardous as some major surgical operations. On the basis of a tremendous experience in private and institutional obstetrics DeLee (1933) stated that puerperal sepsis kills one in every four hundred women delivered of full term children and makes incurable in valid of at least ten times that number. The mortality from criminal abortion is an ever increasing and forbidding figure. This entire

situation is a challenge to modern obstetrics and until healthy young women can have their babies in comparative safety the biggest problem in obstetrics remains unsolved.

**Acute Puerperal Infections**—An oral temperature above 100° F. after delivery usually indicates that infection is present. It may be mild, severe or fatal and it may involve any part of the reproductive system. It may have its origin in a vaginal or perineal tear, a cervical laceration or the placental site. Depending on the resistance of the patient and the virulence of the organism the infection may remain localized or may spread rapidly to surrounding structures producing cellulitis, lymphangitis, phlebitis, abscess or peritonitis. It may invade the blood stream and cause distant metastatic abscesses.

During the acute phase efforts should be made to cause the infection to localize. Foreign bodies such as infected placental tissue should be removed carefully without breaking down the protecting leukocytic wall or opening new vascular spaces. Strict cleanliness is attained by antiseptic douches of a gallon of hot solution of potassium permanganate (1:1000). Peritonitis and sepsis often terminate fatally. Their treatment is beyond the scope of this chapter but it is well to note in passing that the surgical treatment of peritonitis has been revolutionized in the last few years and that results have improved.

Every puerperal infection regardless of its location or apparent insignificance is potentially dangerous. These cases require the keenest observation and the most careful handling. Regard for the finest details makes the difference between success and failure. Surgical intervention is resorted to only when unavoidable for example to drain an abscess or remove infected material from the uterine cavity. Even minor instrumentation and examinations must be performed with meticulous care. The writer is not convinced that it is advisable to ligate the femoral or iliac veins in a case of infected thrombosis or to perform a hysterectomy during an acute puerperal sepsis.

**Chronic Puerperal Infection**—If the patient survives the stage of acute sepsis she may or may not suffer permanent disability. In general the more severe the infection

being learned from cases in which there is recurrence after the use of the sulfonamides.

The method of administration is given in the current literature as well as the dangers that attend use of sulfonamides. These drugs should never be used unless the physician sees the patient often and is alert to the many complications that develop in a definite number of cases.

Every year new sulfonamides are being introduced which vary in their toxicity. In general all sulfonamides must be used with care. Most cases of acute gonorrhea yield to them although as has been indicated chemotherapy has definite limitations in all infections.

In cases that are resistant to sulfonamides penicillin is at times effective. One cannot yet finally appraise its value in gonorrhea because time is an essential criterion in determining the result. Furthermore because of technical difficulties penicillin has not been used very widely. In using penicillin as with sulfonamides one must not expect the impossible for as Herrell has said

penicillin therapy is no substitute for sound medical and surgical judgment in the treatment of bacterial infections and the treatment of gonorrhea still requires all the combined skills of the physician and surgeon.

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and point of view a more descriptive term. The designation leiomyoma is occasionally used.

**Incidence.**—Myomas are found very frequently in the uteri of women in the fourth and fifth decades, being found in about 20 per cent of women over thirty-five. They are much less frequent in women between twenty and thirty years of age but even then are often found. Many of the tumors which are discovered in the thirties began in the twenties. It is not uncommon to see a woman in middle life with a myomatous growth which she has been aware of for many years. New growths do not appear after the menopause but previously existing tumors may slowly increase in size or undergo degenerative processes which may lead to enlargement and render intervention necessary. In clinics in which many colored patients are treated the incidence is greater as there appears to be a racial predisposition to myoma.

**Structure.**—Myomas are made up of a mixture of smooth muscle and fibrous tissue the proportion varying in different tumors. The cut surface of the tumor varies with the proportion of these two tissue elements being firm and pale when it is predominantly fibrous and softer and of a pinkish hue when a considerable proportion of muscle is found.

**Location.**—Myomas are classified according to their relationship to the uterine wall into (1) *interstitial* (intramural), (2) *subserous* and (3) *submucous*. All tumors originate in the myometrium and become subserous or submucous as growth proceeds.

A tumor which grows outward comes to lie under the serosa and is known as a *subserous myoma*. Such a tumor may produce a mass on the surface of the uterus and possibly as it continues to grow become pedunculated. If it grows sufficiently large and its pedicle finally does not afford it an adequate blood supply it may develop a secondary blood supply from other sources usually the omentum. Torsion of the pedicle of a subserous fibroid may occur necessitating immediate intervention.

A tumor which lies near the surface in the lateral wall of the uterus may pass between the leaves of the broad ligament as it grows outward. These tumors are known as *intraligamentary myomas*. They may attain considerable size and sometimes produce pres-



the greater the likelihood that it will result in incapacity. The permanent damage consists of abdominal and pelvic adhesions, chronic infection of the tubes, endometrium, cervix and parametrium, recurring abscesses in the pelvis or broad ligaments and metastatic infections such as arthritis. The streptococcus is the most frequent cause.

The characteristic picture of an old streptococcal puerperal infection consists of pelvic adhesions with open fallopian tubes. This is not like gonorrhea or tuberculosis in which the fundamental lesion is salpingitis and in which tubal closure is practically invariable. In streptococcal puerperal infection the process is primarily an endometritis, cellulitis or peritonitis and the tubes are involved only secondarily. This explains the frequent possibility of pregnancy after puerperal peritonitis.

Endometritis and cervicitis may persist indefinitely, causing menstrual disturbances, leukorrhea, pelvic pain and backache. The writer has isolated the streptococcus in pure culture from the endometrium three years after complete symptomatic recovery from puerperal peritonitis, the indication for the examination being the development of severe polyarthritis. Such latent infections in the pelvis are a continual menace; they may flare up at any time, especially after curettage, cervical cauterization or miscarriage, and they are always likely foci of metastatic infection.

At times it is very difficult to localize a puerperal infection, particularly in the extraperitoneal space of Retzius or between the upper layers of the broad ligament near the pelvic wall. In these locations infections have remained undetected for months, causing fever, obscure pelvic pain and invalidism. Obesity greatly increases the difficulty of making a diagnosis. Eventually, however, careful palpation usually reveals induration along Poupart's ligament or deep in the suprapubic region, and on bimanual examination a corresponding sensitive area of induration or mass is found. Such purulent collections must be opened extraperitoneally, just above Poupart's ligament or above the pubis. Since they are almost always due to the streptococcus and are extraperitoneal, it is vital that the peritoneum should not be opened.

The usual case, marked by pelvic adhesions, uterine misplacement, cervicitis and perineal laceration, is a vicious mixture of the mechanical injuries caused by labor and the damage done by a puerperal infection. The treatment is a complicated major gynecological problem. The nature of the operation depends on the age of the patient and the condition of the pelvic organs. In general, the diseased structures should be removed and the pelvis should be restored to such a condition that other organs, though perhaps slightly involved, may again become healthy. Mechanical faults should be corrected. In young women the treatment should be conservative if possible. In older women near the menopause, however, questionable organs should be removed without hesitation.

In general, the surgical treatment of chronic puerperal infection should be conservative, for it is always fraught with danger. The longer operation can be deferred the better. Even minor instrumentation may reactivate an infection which for years has been dormant.

#### CHEMOTHERAPY IN PELVIC INFECTIONS

The treatment of pelvic infections has been greatly facilitated by the sulfonamides. They are particularly useful in those infections which are due to the gonococcus and the beta hemolytic streptococcus. They are therefore of wide use in gynecological and puerperal infections.

Sulfadiazine, sulfathiazole and sulfamida are effective in gynecological infections, but there are certain definite limitations to their use. Thus in chronic infections which are enclosed in pockets, such as chronic salpingitis, tubo-ovarian infection and deep infections in the perineal or perivaginal glands or cervix, these products are useless except for palliation. These deep closed foci must be eradicated surgically in order to eliminate the infection.

The sulfonamides are useful, however, in acute open infections, such as mark the onset of these diseases. In acute salpingitis, acute pelvic peritonitis and other acute infectious processes, the sulfonamides are usually effective, shortening the course of the disease. But one cannot assume that relief of symptoms means cure of the infection, as is

being learned from cases in which there is recurrence after the use of the sulfonamides.

The method of administration is given in the current literature as well as the dangers that attend use of sulfonamides. These drugs should never be used unless the physician sees the patient often and is alert to the many complications that develop in a definite number of cases.

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## TUMORS OF THE UTERUS

### I. BENIGN TUMORS

#### MYOMA

(Fibroid Fibromyoma Leiomyoma)

The term myoma is preferable although the word fibroid is in common use in this country. Fibromyoma is from the anatomical

point of view a more descriptive term. The designation leiomyoma is occasionally used.

**Incidence.**—Myomas are found very frequently in the uteri of women in the fourth and fifth decades being found in about 20 per cent of women over thirty-five. They are much less frequent in women between twenty and thirty years of age but even then are often found. Many of the tumors which are discovered in the thirties began in the twenties. It is not uncommon to see a woman in middle life with a myomatous growth which she has been aware of for many years. New growths do not appear after the menopause but previously existing tumors may slowly increase in size or undergo degenerative processes which may lead to enlargement and render intervention necessary. In clinics in which many colored patients are treated the incidence is greater as there appears to be a racial predisposition to myoma.

**Structure.**—Myomas are made up of a mixture of smooth muscle and fibrous tissue the proportion varying in different tumors. The cut surface of the tumor varies with the proportion of these two tissue elements being firm and pale when it is predominantly fibrous and softer and of a pinkish hue when a considerable proportion of muscle is found.

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A tumor which grows outward comes to lie under the serosa and is known as a *subserous myoma*. Such a tumor may produce a mass on the surface of the uterus and possibly as it continues to grow become pedunculated. If it grows sufficiently large and its pedicle finally does not afford it an adequate blood supply it may develop a secondary blood supply from other sources usually the omentum. Torsion of the pedicle of a subserous fibroid may occur necessitating immediate intervention.

A tumor which lies near the surface in the lateral wall of the uterus may pass between the leaves of the broad ligament as it grows outward. These tumors are known as *intra-ligamentary myomas*. They may attain considerable size and sometimes produce pres-

oma to be one to forty. Stout believes that the great majority of sarcomas begin in fibromyomatous uteri.

**Symptoms.**—Frequently a woman is found to have one or more myomas in the uterus which have caused no inconvenience whatever. Symptoms are dependent far more on the location of the tumor in the uterus and on its relationship to the uterine canal than on its size. A subserous tumor of considerable size in the fundus may cause no trouble while a smaller one directly under the mucosa may be associated with bleeding.

The most common symptom is bleeding but all fibroids do not bleed. Large tumors are often seen which have caused no loss of blood. Submucous tumors are most frequently the cause of bleeding usually menorrhagic in character due to the cyclic increase in the blood content of the uterus at menstruation and to the fact that the delicate reticulum of vessels under the endometrium which lies over the tumor is broken by the contraction of the uterus as it expels the menstrual blood. Pressure on the endometrium by the tumor itself probably aids this process. As the myoma grows the bleeding period may become longer, so that the part of the monthly cycle which is free from bleeding may become quite short. Again infected necrotic submucous tumors may produce severe metrorrhagia. The menorrhagia accompanying myoma may cause severe secondary anemia. In the menopausal years dysfunctional bleeding is common. In many cases of this sort small myomas may be found but they may play no part in the production of the bleeding.

Pain may be felt in widely varying degree. There may be no sensation at all, only a feeling of mild discomfort or pain may be moderate or very severe. When there are heavy masses a sense of weight may be experienced and very large tumors may interfere with bodily functions producing respiratory difficulty or disturbance of the digestive tract.

The bladder will withstand much distortion so long as its ability to contain a normal amount of urine and to empty itself is not disturbed, no vesical symptoms may appear. When these are interfered with distress is felt. Discomfort caused by pressure

backward on the rectum is rare. A tumor of moderate size in the lower uterine segment will produce more pain than a larger one in the upper part of the uterus as in the latter case far more room is found for expansion. The attempts of the uterus to expel a pedunculated submucous tumor may cause cramping pains and the torsion of a pedunculated subserous growth may produce agonizing suffering.

**Diagnosis.**—Differentiation must be made from pregnancy, inflammatory masses, ovarian neoplasms, endometriosis and in the case of small tumors on the posterior wall retrodisplacement. Any of these may be found together with myoma. If a mass is felt above the symphysis it is usually either a myoma or a pregnancy. A soft symmetrical myoma may simulate pregnancy closely. Amenorrhea accompanies the latter. If necessary the Ashheim-Zondek test will usually distinguish between them. An irregular firm mass is usually a myoma. Ovarian cysts especially if they are tense and adherent may be confused with myomas. Motion transmitted from the abdominal hand on bimanual examination to the vaginal finger speaks for a uterine tumor. Submucous tumors may be difficult to recognize by palpation as the uterus may be but little enlarged and the symmetry but slightly altered.

**Treatment.**—From the therapeutic viewpoint myomas may be divided into three classes: (1) those which need no treatment, (2) those which may be irradiated and (3) those which should be removed surgically.

There are many myomas which need no treatment. Small symptomless tumors may be left alone but those from which symptoms arise need some form of treatment. Small subserous growths may be quite innocuous and may remain so for long periods of time or permanently. A tumor of moderate size at the fundus may be quite harmless while one of the same size in the lower uterine segment owing to the limited space surrounding it may cause serious trouble. When an expectant course is decided on the woman should be counselled that reexamination at intervals should be carried out in order that changes in size of the growth may not escape attention.

A limited number of myomas may be

managed by irradiation radium being preferable. The cases must be carefully chosen. Young women should not be irradiated since the dosage that is necessary to control bleeding is sufficient to destroy ovarian activity. If intervention is needful in these cases operation is better. Irradiation is best

which may be produced in these growths. Previous operation or pelvic inflammation which may have left adhesions renders irradiation unwise since a loop or loops of intestine may be immobilized in such a way as to hold it within range of the radium rays for the entire period of treatment and seri-

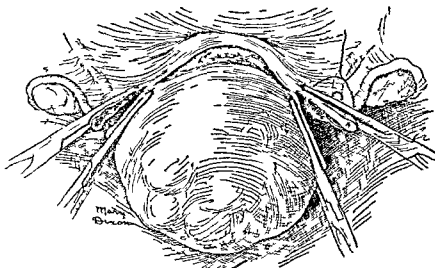


Fig. 668.—Subtotal hysterectomy—author's technique. The broad ligaments are clamped, the round ligament being included. The ligaments are divided. A figure of eight suture ligature controls the broad and round ligaments; the middle loop of the suture preventing the center of the ligated structure from escaping. After the broad ligaments have been divided, the uterovesical fold of peritoneum is divided. Downward dissection need not be carried far.

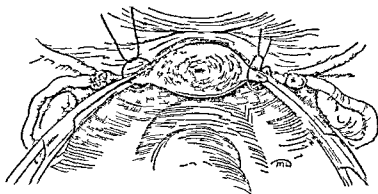


Fig. 669.—The uterus has been amputated at about the level of the internal os; the excision being wedge shaped so as to facilitate closure. The uterine arteries are ligated with a suture ligature catching a little of the tissue of the cervix to avoid slipping. This is shown on the left of the drawing. It is tied under the forceps and is then tied a second time over the end of the forceps which is then removed. This doubly ligates the vessel.

restricted to women well over forty years. It is better not to irradiate tumors over the size of a three month pregnancy. Pelvic infection past or present excludes irradiation because of the danger of recrudescence of inflammation. The presence of ovarian neoplasms renders irradiation unwise because of the possible degenerative changes

ous injury to the intestinal wall may result. Submucous tumors and those which cause pain should be excluded.

If operation is contemplated the following procedures may be considered. I. Abdominal operations: (1) subtotal hysterectomy with or without excision of the adnexa; (2) total hysterectomy and (3) myomectomy.

II. Vaginal operations: (1) vaginal hysterectomy and (2) vaginal myomectomy.

The most useful and most frequently performed operation for the treatment of myoma is subtotal or supravaginal hysterectomy

is present or when the cervix is notably unhealthy. Recent publications indicate that the incidence of carcinoma in the retained cervical stump after subtotal hysterectomy is about 2 per cent. The stump sometimes

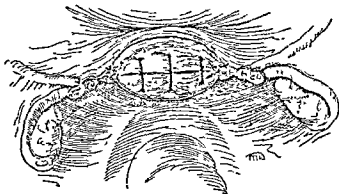


Fig 670—The cervical stump is closed by two or three anteroposterior sutures which do not include the peritoneum

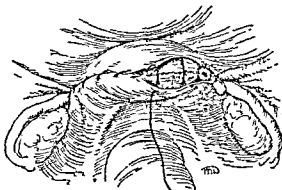


Fig 671—Peritonization is begun by a suture which passes through the anterior peritoneal edge, the round ligament, the tube (or the infundibulopelvic ligament if the adnexa are removed) and the posterior peritoneum. When this is tied, the ligamentary stump is inverted and covered. The suture continues across to the opposite side. The opposite stump is similarly buried.

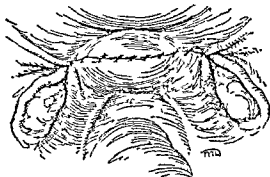


Fig 672—Peritonization is completed. The stumps of the broad and round ligaments are not fixed to the stump of the cervix unless this can be done without any tension. The ovaries are left movable and in approximately their normal location.

tomy. The ovaries should be preserved whenever possible. The younger the patient the greater is the importance of maintaining ovarian activity. Total hysterectomy should be done when cancer of the

causes leukorrhea which does not respond well to treatment. For both of these reasons, of late years, total hysterectomy has come to be more frequently employed in active gynecological clinics. Expert pelvic surgeons

can do the total operation as safely as the subtotal but this is not true of operators of lesser experience. Careful postoperative studies of large series of cases indicate that at least in the hands of the average operator the added risk of the more extended operation is greater than the danger of the development of cancer in the retained stump. When carcinoma appears soon after subtotal hysterectomy this usually means that malignant disease was overlooked at the time of operation. If carcinoma of the corpus is suspected the excised uterus should be opened for inspection before the abdomen is closed so that if carcinoma is revealed the cervix may be removed at once.

Vaginal hysterectomy is of use when the tumor is small particularly if plastic work also is to be done but it requires a greater degree of technical skill. Although a larger tumor may be removed vaginally by a surgeon skilled in this mode of approach the abdominal route is wiser if the growth is bulky.

A submucous pedunculated tumor which protrudes through the cervix into the vagina should be removed by vaginal myomectomy. These tumors are always infected and intervention should be as simple as possible. The pedicle should be located which as the cervix has dilated to allow the escape of the tumor is usually easy. It is then grasped with a clamp and divided and the tumor removed the clamp being allowed to remain for twenty-four hours. Sutures should not be used. If other myomas are present in the corpus operation for their removal should be deferred for several weeks. Operation is always hazardous if performed before the complete subsidence of the infection which accompanies a pedunculated growth that has escaped into the vagina. Failure to observe this precaution will subject the patient to grave danger.

### POLYPS

Polyps are growths which arise from the mucosa of the corpus or cervix and may be single or multiple. The term polypoid endometritis has been used to designate a condition characterized by the presence of many polyps in the corpus. Cervical polyps are usually preceded by long standing cervical endometritis. They may project

through the external os. The size may vary but they are usually small. Cervical polyps may become necrotic through interference with their blood supply. Malignant change is not common but does occur. Cervical polyps may grow rapidly during pregnancy.

**Symptoms and Diagnosis.**—Cervical polyps are readily seen through a speculum. They are smooth round red masses from 0.5 to 1 cm in diameter presenting at the external os or protruding through it. More than one may be present at a time. Bleeding is a common symptom and is irregular and usually slight in amount. Exceptionally free bleeding may be present. No pain is felt.

**Treatment.**—A small polyp may be grasped as high as possible by a dressing forceps and twisted off. A larger one may be removed by a wire snare. If bleeding follows then packing may be needed. If the pedicle is visible it may be divided by the cautery. If a number of polyps are present the cautery may be used. If the endocervicitis remains other polyps may develop later. Permanent relief will follow the correction of the endocervicitis by means of plastic surgery.

### ADENOMYOMA

An endometrial invasion of the uterine wall with accompanying muscular hyperplasia is now usually termed adenomyosis. It is produced by extension into the uterine wall of a growth of endometrium or by metaplasia of the scarra covering the corpus. Sampson believes the latter to be rare and that posterior adenomyosis at least is caused by the proliferation of endometrium which reaches the rectovaginal pouch through the tubes. The growth is usually small but may grow to the size of an orange. It is more often found in the posterior wall and may be found with myoma. Microscopically areas of typical endometrial tissue are found which show no evidence of menstrual activity and are surrounded by an area of cytogenic stroma.

The differential diagnosis from myoma is usually impossible to make. The most characteristic symptom is menstrual hemorrhage the bleeding being increased as to length and amount. Marked anemia may develop. The best treatment is hysterectomy. Radium is often ineffective.

## II MALIGNANT TUMORS

## CARCINOMA

**Carcinoma of the Cervix**—Carcinoma of the cervix is far more frequent than carcinoma of the corpus about 80 per cent of uterine carcinomas being found in the cervix. The tumor is usually found in younger patients than is corporeal carcinoma. Cullen found that 72 per cent of the patients in his series were between thirty-five and fifty-five. Under twenty years it is rare. Women who have borne children especially those who have had several labors show a marked predilection for cancer. Frank's series for example showed only 3 per cent of nulliparae.

It is not established that carcinoma begins in the seat of an old laceration. It is certain however that an excited eroded irritated and profusely discharging cervix is far more frequently the seat of malignant disease than a healthy one. Plastic restoration of the diseased cervix or the healing of excision by the cautery reduces the danger of malignant disease. Improper technique in the use of either of these may cause stricture of the cervix.

**Pathology**—The simplest classification is that of Ruge-Veit which divides cervical carcinomas into two classes—carcinoma of the portio vaginalis and carcinoma of the cervix proper. The former arises from the visible vaginal portion of the cervix and the latter from the cervical canal between the external os and the upper limit of the cervix. Carcinoma of the portio vaginalis as a rule is of the squamous cell or epidermoid type while cervical cancer is adenocarcinomatous. In a far advanced growth it may be difficult to tell the point of origin of the tumor and even the microscopic appearance may not definitely indicate where the growth began. In some cases the two types of carcinoma may be combined. The squamous cell type is by far the more frequent.

Classifications as to the degree of malignancy based on the predominating cellular type have been made by Broders and Martzloff but their prognostic value is a matter of opinion. In estimating curability one must also consider the age of the patient the degree of advancement of the growth as evidenced by the visible growth the degree

of fixation of the uterus and the degree of the parametrial invasion.

Adenocarcinoma of the endocervix may reproduce the alveolar structure of the epithelium or the lumina of the alveoli may be filled by the ingrowing of cells.

As the cancer increases in size it tends to necrose on the surface and a breaking down of the superficial tissue occurs with crater formation. This may produce a watery discharge and a foul odor the result of the invasion of the necrotic area by the saprophytic microorganisms of the vagina. The necrotic process may erode the blood vessels of the cervix and produce bleeding. Frequently by the time that bleeding appears the growth has already progressed so far that hope of cure is small.

Extension of carcinoma of the portio vaginalis may occur to the adjacent vaginal wall. Extensive invasion anteriorly may ultimately produce a vesicovaginal fistula. Posterior progression may involve the rectum and produce a rectovaginal fistula. Lateral extension of the carcinoma may occur into the parametrium with eventually firm fixation of the uterus. A part at least of the early fixation may be due to the infection which is present in the necrotic masses and which may extend into the parametrium. Extension of cancer of the portio vaginalis occurs earlier and is more extensive than is the case in cancer of the corpus because the epidermoid type of cancer which is found in the portio vaginalis is a more rapidly growing type of carcinoma than the adenocarcinoma of the corpus. Lymphatic drainage from the cervix is more extensive than from the corpus.

Extension by invasion of contiguous tissue permits more extensive growth in cancers of the portio than in those of the corpus. Extension along epithelial surfaces is frequent in carcinoma of the portio. Cervical carcinoma may extend upward and involve the corpus usually by continuity after the entire extent of the cervix has been invaded. Extension may occur into the lymphatics of the pelvis and lower abdomen. Metastases may occur in the broad ligaments and compression of the ureter may be found in advanced cases with hydronephrosis and hydro-nephrosis. Obstruction of the cervical canal may produce a prometry.

*Symptoms*—It is unfortunate that uterine carcinoma produces no early symptoms. Bleeding is usually the first sign which attracts attention and may be small in amount and intermenstrual. Increased flow which is always associated with the periods is not suggestive of cancer. Any irregular bleeding particularly in a woman in the fifth or sixth decennium should be regarded with suspicion. Bleeding which follows slight trauma such as digital examination, coitus or douching is suggestive but bleeding which comes on after the menopause is particularly suggestive. There are other causes which may produce postmenopausal bleeding but carcinoma must always be seriously considered. It is well to consider all cases in which bleeding occurs after the menopause has been well established as cancer until some less serious cause can be demonstrated. A discharge other than blood may appear which is usually watery and possibly foul; this is usually a late development of cancer.

Symptoms referable to the urinary tract are usually noted in late cases. If these are present when the patient is first seen the probability of cure is small. Loss of weight and cachexia are late manifestations.

*Diagnosis*—A late case with extensive cauliflower-like masses on the cervix, extension on the neighboring vaginal mucosa and fixation of the uterus is easy of recognition. Bleeding at contact with the examining finger and friability of the mass are characteristic.

Ulceration is found in relatively early cases and may vary from a small localized lesion to a complete destruction of the cervix. In the latter event a large crater-like area may be found.

In order to obtain an increase in the number of cures the recognition of a greater number of cases must be made sufficiently early that the growth can be removed in its entirety.

only necrotic tissue may be secured. The cells in such a piece are so altered by necrosis that accurate diagnosis is impossible. The danger of spreading malignant disease by biopsy is probably not as great as has been feared by some writers. If an electric knife is not available the area from which the biopsy specimen is taken should be touched with formalin. If carcinoma of the corpus is feared diagnostic curettage may be performed. If large pieces of tissue can be curetted away easily and if the uterine wall feels soft under the instrument a malignant growth should be suspected. Frozen sections of curetted material have only a qualified value. If large pieces are obtained from a carcinomatous area satisfactory sections may be obtained. If only small bits are available unless all are stained and examined the cancerous area may be missed. Trauma may lessen the value of curetted material.

*Treatment of carcinoma of the cervix* may be by (1) radical excision—abdominal or vaginal, (2) irradiation—radium or deep x-ray or (3) heat—actual cautery or electrocoagulation.

At present in most clinics in this country radium treatment is the method of choice in carcinoma of the cervix. Unless the cancer is very early the surgical excision must be so radical that the primary operative mortality is high even in the hands of expert pelvic surgeons. The extended hysterectomy should not be attempted unless the parametrium is free and the rectum and bladder show no sign of extension. Vaginal invasion must be absent or so slight that it can be excised. The radical vaginal operation first described by Schauta is advocated by some European writers; an excellent discussion of this procedure is given by Pecham and Amreich. Ordinarily hysterectomy is not only useless but harmful.



greatest part of the effectiveness of radium is exerted at the first application. The practice in many clinics today is to irradiate both by radium and by x ray. Results seem to have been improved by this combination. The details of x ray therapy are for the radiologist to decide upon but in general it may be said that deep therapy through a number of portals is best. Preliminary destruction of the visible portion of the tumor by electrocoagulation increases considerably the effectiveness of irradiation.

**Carcinoma of the Corpus.**—Carcinoma of the corpus is much less frequent than carcinoma of the cervix. It is usually an adenocarcinoma. The rate of growth is less than that of cervical cancers and metastasis occurs later and is not so extensive.

**Diagnosis.**—The uterus may be somewhat enlarged and relatively symmetrical. Irregular bleeding is the outstanding symptom. Bleeding in a woman well past the menopause after some years of amenorrhea with no other obvious cause of bleeding is highly suggestive if not pathognomonic. Curettage may be employed with histologic examination of the scrapings. It should be done gently as the carcinomatous organ is easily perforated and the danger of migration of malignant cells through the tubes with implantation in the peritoneum must be borne in mind.

**Treatment.**—In cases of carcinoma of the body of the uterus surgical treatment is preferred unless there is evidence of extension beyond the uterus. Excellent results are obtained by excision of the uterus including the cervix tubes and ovaries. The extended operation of Wertheim and Ries is not necessary. In cases in which extension beyond the limits of the uterus has occurred radium or x ray treatment may be employed instead of operation. Burnham reports 109 per cent of advanced cases of corpus carcinoma treated by irradiation alone. Healy suggests the value of irradiation in cases favorable for operation and with Cutler reports 63 per cent of cures in a series of 23 cases.

### CHORIONEPITHELIOMA

Chorionepithelioma is a highly malignant tumor. Since its appearance except in rare cases is preceded by the presence of fetal cells it therefore follows hydatid mole abor-

tion or possibly term pregnancy. Meyer has shown that the formation of a mole in an aborted embryo is very common. The possibility that a chorionepithelioma may develop after abortion is therefore evident. Chorionepithelioma may be preceded by hydatid mole but it is by no means true that every hydatid mole is followed by chorionepithelioma. It is found during the years of child bearing. In Tercher's series of 189 cases the average age was thirty three. The tumor usually appears soon after the termination of pregnancy. After three years its appearance is uncommon but longer periods are possible. Ries found chorionic villi in the uterus eighteen years after the last pregnancy.

Rapid metastasis is a marked characteristic and is often by way of the blood stream as a result of erosion of vessels in the uterus. The lungs are the most frequent site of secondary growths the vagina and vulva being next in frequency. Metastases may also be found in the liver urinary tract broad ligaments tubes and ovaries.

**Symptoms.**—The symptoms are often vague until the growth has developed beyond the possibility of removal. Pulmonary metastases causing hemoptysis and cachexia may be the first symptom. Bleeding following the expulsion of a hydatid mole is always suspicious. Diagnostic curettage should be performed at once followed immediately by surgical treatment if chorionepithelioma is found. The prognosis is bad death usually following within a year. There are however cases recorded of recovery after simple curettage.

**Treatment.**—Every hydatid mole should be completely evacuated. Schumann advocates abdominal hysterectomy in order that evacuation of the uterus may be performed under direct observation. If chorionepithelioma is found panhysterectomy with excision of the pelvic glands must be performed at once. Theoretically radium should be of great value because cells of fetal character are susceptible to it, but sufficient data are not yet available to make an accurate estimation of its value possible.

### SARCOMA

Sarcoma is found infrequently. A number of reported series indicate that the number

of sarcomas is between 1 and 2 per cent of that of myomas. They are most frequent between the ages of forty and fifty. Veit reported a few cases in young women and children, the frequency increasing from twenty-five years upward. It is more frequently found in the corpus than in the cervix. The recurrent fibroids spoken of by some older writers were probably sarcomas. Both round cell and spindle cell sarcomas may be found. Mixed cell growths are also described.

**Symptoms**—Bleeding which is irregular and not associated with menstruation usually after the menopause is typical. Pain is frequent and may be caused by pressure on neighboring structures or by the rapid growth of the sarcoma. A sarcoma which develops in the cervix or lower uterine segment may produce rectal or vesical pain and a watery discharge may appear. In later cases in which sloughing has begun the discharge may be foul. Diagnostic curettage may be of value.

**Treatment**—If the condition is recognized early, when the growth is still confined to the uterus, radical hysterectomy including the removal of the pelvic lymphatic glands is best. In later cases in which extension has occurred irradiation should be used preferably with radium which may be followed by x-ray treatment.

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#### TUMORS OF THE OVARY

Ovarian tumors may be solid or cystic, about 95 per cent being cystic. Both cystic and solid tumors of the ovaries are usually benign. Carcinoma and sarcoma develop relatively infrequently.

**Ovarian Cysts**—The genesis of ovarian cysts is not known. They may be divided into the following groups:

1 *Simple follicular cysts*—multiple usually bilateral and small, consist of unruptured graafian follicles from which the ova have usually disappeared. Either the walls are lined by flattened cylindrical epithelium or there is no epithelial lining. The cysts contain serum, either clear or turbid. Disturbances of the ovarian circulation appear to play a part in the etiology, as in uterodisplacement with prolapse of the ovaries or venous stasis incident to uterine involution.

2 A *serous cyst* differs from a follicular cyst in possessing an epithelial lining, unlike that of the follicle and displaying active proliferation (single layer of columnar epithelial cells). Unlike the cystadenoma, there are no proliferating gland tubules in the cyst wall. The serous cyst is usually unilocular and pedunculated but may be intraligamentous. It is usually moderate in size but may attain enormous dimensions. In general it is unilateral and always benign. (Figs. 673 and 674).

3 A *cyst of the corpus luteum* is usually single and unilateral, arising from a persistent corpus luteum. It may have orange-colored walls. Rarely does such a cyst exceed 6 cm. in diameter. Hemorrhage into the cyst cavity is common. These cysts are benign. Cases of hydatidiform mole are sometimes associated with large bilateral cysts of the corpus luteum, caused by an excess of anterior pituitary like hormone. An excess amount of this hormone causes hyperlutinization and sometimes hyperfolliculization.

These cysts may retrogress with the expulsion of the mole, but in many instances they persist although reduced in size. They should not be excised immediately, but a reasonable period should be allowed to elapse after the extraction or expulsion of the mole in order to determine whether or not retrogression will take place.

4 *Endometrioid cysts* (chocolate cysts) en-

ometriosis) may be multiple and unilateral or bilateral. They arise from misplaced endometrial implants on the surface of the ovary and contain thick, curdy, altered blood. The walls are thick, and many areas of characteristic endometrial glands may be seen

embryonal structures ectoderm in greatest development then mesoderm and lastly endoderm. Barzilai has defined *teratomas* as adult or embryonal forms. The mature teratoma is microscopically polymorphous and often cystic (dermoid cyst) and it usually



Fig. 3—Large serous cyst of the ovary (a thoracic case at the K. S. Hospital for Women Philadelphia)

microscopically. Such cysts frequently rupture, allowing the escape of some of the endometrial membrane and producing endometrial implants throughout the pelvis.

5. *Dermoid cysts* are usually unilateral and congenital. They are spherical masses

showing overgrowth of one tissue such as skin or thyroid tissue to the exclusion of all others. The adult teratoma is benign. The embryonal teratoma is generally a solid growth made up of many tissues and is highly malignant.

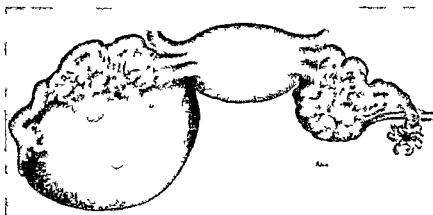


Fig. 4—Large dermoid cyst

ing from 15 to 20 cm. in diameter. The capsule is firm and white but turns yellowish on exposure to the air as a result of the coagulation of sebaceous material. The contents may be hair, bone, teeth, or sebaceous matter. All such cysts possess a small thickened area on the wall which contains all three em-

6. *Cystadenomas* (pseudomucinous cysts) are characterized by the presence of rapidly proliferating gland tubules lined with a single layer of secreting epithelium. The cysts distend and rupture into one another and cavities of various sizes result. They may be unilateral or bilateral and they grow

to huge proportions cysts weighing from 175 to 190 pounds having been recorded. A cyst of this size causes stretching of the ovarian attachments into long pedicles. However as a rule they are much smaller 20 or 30 pounds being an average weight. The contents may be clear serum thick colloidal jelly grumous syrupy fluid old blood etc. The surface is always smooth and the contour globular. These cysts are usually benign. They sometimes rupture into the peritoneal cavity and the proliferating epithelium becomes implanted on remote structures producing pseudomyoma peritonei.

present masses of colloidal material intermingled with areas of fused papillae. They are adenocarcinomatous have a rapid growth and become ascitic early. Pain is a common symptom.

9 *Parovarian cysts* arise from the parovarium a remnant of the Wolffian body. They are unilocular and unilateral and grow between the leaves of the broad ligament. They are thin walled and flaccid and are recognized by the fact that in each case the fallopian tube is stretched over the surface of the cyst and enormously elongated and thinned out. The uterus is displaced as is the ureter making operation difficult. The



Fig. 63.—Multilocular papillary carcinoma of the ovary.

7 *Papillary cystadenomas* may attain a large size and are potentially malignant though in low degree. They are multilocular and thick walled and frequently rupture by erosion of papillae through the cyst wall producing secondary papillary growths throughout the peritoneal cavity. Microscopically the papillae of varying length and thickness are seen covered with columnar epithelium and sometimes massed as large condylomatous nodules.

8 *Cystic carcinomas of the ovary* (Fig. 675) may be primary (disputed) or the result of the degeneration of a cystadenoma. They are commonly bilateral and are difficult to distinguish from papillary cysts except by their greater solidity. They often

true wall of the cyst is covered by the broad ligament making a double wall. A pedicle is usually absent.

**Solid Tumors of the Ovary**—These are rare. They may be classified as follows:

1 *Fibromas* are usually of moderate size (12 to 15 cm. in diameter) and either solid or partially papillary. They tend to become malignant. The wall is smooth and the pedicle usually well developed. The tumor may be partially or completely calcified.

2 *Sarcoma of the ovary* is rare, commonly bilateral and round or spindle cell. It may be smooth or nodular; metastasis is slow.

\* Curtis, *Obstetrics and Gynecology*, W. B. Saunders Co., Publishers.

3 *Granulosa cell tumors of the ovary* are rare semeystic tumors usually unilateral small to moderate in size and well encapsulated. Microscopically these growths resemble the granulosa cells of the normal ovary and have a tendency to form structures resembling graafian follicles and follicular cysts. They are probably benign although some appear to possess malignant characteristics. In elderly women granulosa cell tumors stimulate the endometrium and produce uterine bleeding. In children they characteristically give rise to precocious sexual development.

4 *Krukenberg tumors* are malignant growths usually secondary to gastrointestinal carcinoma. They are firm solid growths generally bilateral kidney shaped and sometimes lobulated.

5 *Brenner tumors* are now classed as benign. They vary greatly in size and resemble fibromas without a definite capsule.

6 *Dysgerminomas* arise from undifferentiated gonadal cells occasionally reach enormous size and are classed as malignant although the malignancy varies in different individuals.

7 *Arrhenoblastoma* is a masculinizing tumor originating in certain male-directed cells which persist in the ovary from early embryonal life.

**Clinical Course and Symptomatology.**—Benign ovarian tumors usually do not give rise to symptoms unless complications occur. The smaller cystic and solid growths are often unrecognized unless discovered by pelvic examination.

The larger tumors cause an increase in size of the abdomen and pressure symptoms later. Exceptions to this rule are endometrial cysts and the small follicular cysts. Occasionally disturbances of menstruation are present and a sense of weight is felt in the pelvis. Bilateral tumors usually give rise to amenorrhea.

Ovarian tumors grow slowly but steadily and eventually reach a large size. If not removed they may cause death from pressure on vital organs.

By pressure the larger tumors cause (a) irritability of the bladder (b) edema of the lower extremities (c) malnutrition with loss of flesh (d) menstrual irregularities (e) constipation and (f) ascites. There are no

specific symptoms. Endometrial cysts cause severe dysmenorrhea with menorrhagia and metrorrhagia and are sometimes extremely tender causing dyspareunia. Multiple follicular cysts cause great menstrual irregularity and frequently sterility and some times are the cause of a dull heavy aching in the iliac fossae.

**Diagnosis.**—The size of the tumor must be considered.

A small tumor presents a vague history of some menstrual disorder or bladder irritability. Bimanual examination reveals a rounded fluctuating mass which is independent of the uterus. The mass may be anterior to the uterus in close approximation to the bladder. It may be fixed or movable. Usually the uterine corpus can be differentiated from the cyst but sometimes this is impossible. Tenderness is uncommon except in endometrial cysts. These are often fixed the outline usually being irregular and nodular. Large ovarian cysts may extend from symphysis to ensiform cartilage and may be smooth movable (sometimes very tender) and fluctuating with dullness over the tumor and tympany in the flanks. The abdomen is distinctly rounded (not flattened as in ascites) in profile when the patient is lying on the back. Pelvic examination is uncertain there is a sense of fullness in the vaginal fornices.

**DIFFERENTIAL DIAGNOSIS.**—A small ovarian cyst must be differentiated from (1) salpingitis and hydrosalpinx (2) ectopic pregnancy and (3) retroverted pregnant uterus.

1 *Salpingitis and hydrosalpinx* are characterized by (a) a history of an acute attack (b) marked tenderness (c) irregular outline (d) fixation in the pelvis (e) its frequent blending into the uterine outline (f) height of temperature leukocytosis and rapid sedimentation time.

2 *Ectopic pregnancy* is characterized by (a) a history of a missed or irregular period (b) slight uterine bleeding (c) pain sudden and afebrile (d) painful defecation (e) soft cervix slightly enlarged and softened uterus (f) positive Aschheim Zondek test and (g) an ovoid extremely tender mass in the vaginal fornix.

3 *Retroverted pregnant uterus* is characterized by (a) a history of pregnancy, (b)

positive Aschheim Zondek test (c) a mass in the median line and (d) objective signs of early pregnancy

**B Large ovarian cyst** must be differentiated from (1) ascites (2) pregnancy (3) fibroma uteri (4) obesity and (5) giant hydrosalpinx

1 Ascites is distinguished by (a) a history of cardiorenal disease cirrhosis of the liver tuberculous peritonitis or abdominal malignant disease (b) tympany anteriorly movable dullness in the flank (c) abdominal profile which is flat at the apex when the patient is supine and (d) absence of a palpable mass

2 Pregnancy is differentiated by means of (a) subjective and objective signs of pregnancy (b) fetal palpation (c) associated changes in the breasts (pigmentation) etc (d) x-ray plates and (e) an Aschheim Zondek test

3 Fibroma uteri is distinguished by (a) a hard dense usually nodular mass (b) a nodular (usually multinodular) dense tumor springing from the uterus and found on pelvic examination and (c) persistent menorrhagia and metrorrhagia

**Complications of Ovarian Cysts** (1) Rotation of cyst with torsion of pedicle 2 Inflammation suppuration of cyst with peritonitis 3 Rupture of cyst 4 Ureteral obstruction 5 Intestinal obstruction

1 *Rotation of the cyst caused by intestinal movement trauma etc* is frequent Torsion of the pedicle results and from one to seven turns may occur Torsion first produces interference with the venous return and a consequent intense engorgement of the cyst frequently followed by hemorrhage into its cavity Later there may be thrombosis of vessels and extravasation of blood into the abdominal cavity necrosis and gangrene of the cyst followed by general peritonitis The symptoms are sudden pain often following mild trauma or unusual exercise abdominal rigidity distention moderate shock pyrexia leukocytosis vomiting and dysuria Pelvic examination reveals a tense and extremely tender cystic mass

2 *Infection* will cause inflammation and suppuration The symptoms are pain rigidity of the rectum temperature indicative of sepsis rigors high leukocytosis and a rapid sedimentation time Later there are evi-

dences of chronic sepsis followed by rapid anemia and emaciation There is a possibility of rupture of a suppurating cyst into the bladder or rectum or rarely into the peritoneal cavity

3 *Rupture* may follow sharp abdominal traumatism or may result from overdilatation of a thin walled cyst Usually no marked symptoms are present except a change in the character of the abdominal swelling malaise and marked diuresis usually followed by low grade peritonitis Sometimes recovery occurs if the cyst does not refill but more often there is continued leakage

4 *Ureteral obstruction* may be evidenced by oliguria pain in the lumbar fossae pyelitis and pyelonephritis with uremia

5 *Cysts* which become adherent to loops of intestine may cause obstruction followed by the usual signs

**Treatment**—Small ovarian cysts require no treatment but a yearly pelvic examination should be made in order to determine the rate of growth Large cysts demand surgical removal Tapping through the abdominal wall should never be done except to save life from pressure symptoms when a patient is unable to undergo operation Endometrial cysts may best be treated by excision If this is contraindicated irradiation to a menopausal degree may suffice Multiple small follicular cysts may be treated by resection of the diseased portion of the ovary leaving the hilus and as much of the parenchyma as is feasible Endometrial cysts were formerly treated by radical operations but as they commonly occur in young women in whom the preservation of ovarian function is important a more conservative attitude prevails at present Papillary cysts should be removed if possible intact Irradiation should follow because of potential malignancy Dermoid cysts should be removed intact as soon as discovered

**Operative Technique—Resection of the Ovary**—The usual abdominal preparation should be carried out and a midline incision made The cystic ovary is seized with Allis clamps and a wedge-shaped piece is excised care being taken to include all the cystic area The cut surfaces are carefully approximated by a running suture of 0 catgut with

fine mattress sutures occluding the blood vessels (Figs 676 and 677). Uterine suspension prevents prolapse of the ovary into the cul de sac with the formation of adhesions.

*Papillary Cyst*—A large incision is made and every effort exerted to prevent rupture of the cyst and escape of the contents into the abdominal cavity. If the cyst should rupture a careful peritoneal toilet is imper-

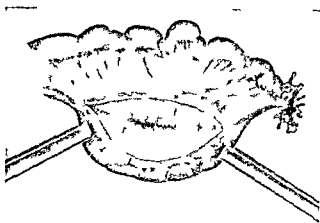


Fig 66—Resection of the cystic portion of the ovary. All cyst tissue must be removed.

*Large Cysts*—Local anesthesia is peculiarly applicable in such cases. A small midline incision is made and the surface of the cyst grasped with Allis forceps; the serosa nicked and a trocar introduced. Gauze packing is used to prevent leakage of fluid. When the tension has been slightly reduced the trocar is fastened in place by purse string

sutures and postoperative irradiation should be used to prevent the growth of malignant cells which may have entered the peritoneal cavity.

A *dermoid cyst* should be removed intact if possible. A cyst of the broad ligament may be extremely difficult to remove. Being thin-walled it collapses easily, leaving a

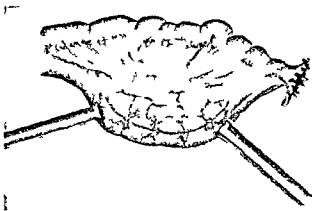


Fig 67—Repair of the wedge-shaped cavity in the ovarian stroma by interrupted sutures of fine catgut.

sutures or several clamps and the cyst emptied. Then the trocar is withdrawn, the opening is closed by clamps and the flaccid cyst wall is gently pulled through the incision, adhesions being cut as they are met. The pedicle is then ligated with chain ligatures and cut. The pedicle stump is peritonized if possible and the wound closed.

large space in the vascular portion of the broad ligament. Great care must be taken not to injure the probably displaced ureter or to include it in the suture when the gap in the broad ligament is being closed. This type of cyst in some cases may be easily removed by enucleation, the broad ligament being opened at its lateral pelvic attach-

ment and the cyst stripped from between its leaves

**Treatment of Complications of Ovarian Cyst**—Torsion of the pedicle demand immediate operation. Ligation of the pedicle and removal of the cyst must be followed by drainage if peritonitis has commenced. Blood transfusion and other supportive measures are frequently necessary to combat shock and infection.

Suppurating cysts should be removed entire if possible. If leakage occurs a careful toilet and drainage are indicated.

Occasionally it is best simply to evacuate the purulent contents of the cyst and suture the cut edge of its wall to the abdominal wall (marsupialization). When infection subsides the cyst may be removed and the wound closed. In cases of follicular serous dermoid and endometrial cysts the opposite ovary if apparently healthy may be allowed to remain. In papillary and pseudo mucinous cysts both ovaries should be removed usually with hysterectomy. If the ovarian cyst is malignant wide panhysterectomy is indicated.

**Treatment**—Fibromas may be excised by simple oophorectomy. A sarcoma or carcinoma demands panhysterectomy with removal of both ovaries followed by intensive postoperative irradiation.

As carcinoma of the ovary is often secondary a careful roentgenographic study of the intestinal tract and other investigations should be carried out prior to operation. The discovery of a primary tumor remote from the pelvis renders useless an excision of the ovarian growth. Complete hysterectomy is the procedure of choice in the absence of metastasis even though but one ovary is involved. If the tumors are inoperable no attempt at removal should be made. Treatment should consist of intensive irradiation.

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## RETRODISPLACEMENTS AND PROLAPSE OF THE UTERUS ETC

### RETRODISPLACEMENTS OF THE UTERUS

The position normally assumed by the uterus is that of anteversion but this position is subject to physiologic changes. Thus the bladder causes the uterine body to drop backward or rise as it becomes filled or emptied. The distended rectum likewise may influence the uterine position. The cervix being more firmly fixed allows less mobility. With the bladder empty the long axis of the uterus is at right angles to the axis of the vagina (Fig. 678 a).

**Definition**—Retrodisplacement of the uterus is a term applied to (a) *retroversion* which is a backward rotation of the uterine body toward the promontory of the sacrum or below that point (Fig. 678 d) (b) *retroflexion* which is a bending backward of the uterine body on itself (Fig. 678 e) (c) *retrocession* which is a dropping backward of the entire uterus (Fig. 678 f).

**Etiology**—(a) *Congenital* retrodisplacements commonly occur in young nulliparous women and (b) *acquired* retrodisplacements occur as a result of (1) childbirth injuries (2) uterine subinvolution (3) neoplasms (4) adnexal inflammation and (5) endometriosis.

**Pathology**—(1) In *congenital* retrodisplacements such as retroflexion and ante-flexion faulty development of the uterine ligaments and fascial supports is usually evident the uterus being hypoplastic in



type. The anterior vaginal wall is commonly shortened.

(B) *Acquired* retrodisplacements result from relaxation of the uterine supports. As a result of retrodisplacements the intestines rest in the vesicouterine pouch, the adnexa drop into the cul-de-sac and the bladder is drawn backward. The backward rotation of the uterine body causes torsion of the blood vessels of the broad ligaments resulting in passive congestion of the uterus and the development of varicosities in the broad ligaments. The fallopian tubes and ovaries become passively congested and formation

a feeling of weight in the pelvis with a bearing down sensation (3) menstrual symptoms such as menorrhagia or dysmenorrhea (4) leukorrhoea resulting from hypersecretion of the cervix (5) dyspareunia occurring if the ovaries are prolapsed in the cul-de-sac (6) frequency of urination if the trigone of the bladder is pressed on, (7) constipation from pressure on the lower bowel and (8) sterility or repeated abortions. The symptoms of retrodisplacement due to an associated pathologic condition are chiefly those of the diseased condition causing it.

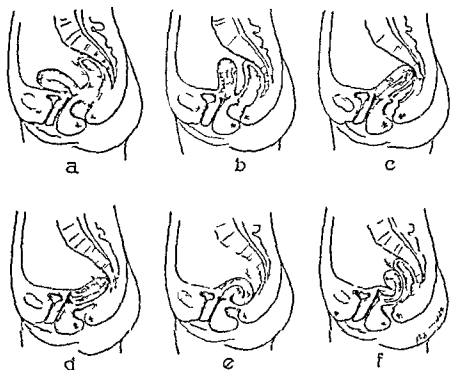


Fig. 68.—a Normal b retroverts on first degree c retroverts on second degree d retroverts on third degree e retroflexion f anteversion with retroversion

of follicular cysts of the ovary may result. Passive congestion of the cervix causes hypertrophy of the musculature and cervical glands. Displacements due to or associated with inflammatory lesions are frequently fixed posteriorly by adhesions.

**Symptomatology.**—(A) *Congenital* retrodisplacements seldom cause symptoms although dysmenorrhea and sterility are often associated and are probably due to faulty development. (B) *Acquired* retrodisplacements may also cause no symptoms. If any are present the most frequent complaints are (1) lumbosacral backache (2)

**Diagnosis.**—The diagnosis of retrodisplacement is made by bimanual examination. Rectovaginal examination is of additional value in making a diagnosis especially in obese women. Myomas of the uterine wall, ovarian cysts and inflammatory exudates behind the uterus may lead to confusion in the diagnosis. In questionable cases a uterine sound may be introduced to determine the position of the fundus but should be used only under strict aseptic precautions and never when pregnancy is suspected.

**Prognosis.**—While congenital retrodis-

placements seldom cause symptoms endometriosis of the pelvis may occur because of retrograde menstruation. Acquired retrodisplacements predispose to prolapse of the uterus.

**Treatment**—Symptom free patients require no treatment. Retrodisplacements occurring after childbirth are often corrected by means of the knee chest position. Others require replacement and support by a suitable pessary until involution is complete. Retrodisplacements with associated vesical discomfort and frequency of urination require careful study of the urine as cystitis may be the cause. Uterine replacement and retention in a normal position with a pessary is a reliable test to determine the amount of relief obtained. If symptoms disappear surgical treatment is usually advisable provided there is no contraindication.

Operative measures for the correction of retroversion are most satisfactorily performed intra abdominally. They should be devised so as to use the natural supports of the uterus to insure mobility to allow pregnancy to occur to be easy of execution and to be lasting in their results (Gilliam). Coffey's anterior plication and the Baldwin Webster posterior plication of the round ligaments are satisfactory procedures. Gilliam's operation of pulling the round ligament through a stab wound made through the rectus muscle and suturing it to the anterior sheath is also a satisfactory procedure. In most instances the uterosacral ligaments should be shortened in addition to the round ligament plication.

#### PROLAPSE OF THE UTERUS URETHROCELE, CYSTOCELE, ENTEROCELE AND RECTOCELE

These lesions are all true hernias of the pelvic viscera into or through the vaginal canal. Since they have a common cause and are frequently associated they are best studied collectively.

**Synonyms and Definitions**—*Prolapse of the uterus* (*procidentia descendens uteri* or falling of the womb) is a permanent descent of the uterus from its normal position (Fig. 679). *Urethrocele* is a prolapse of the urethra (Fig. 680). *Cystocele* is a hernia of the base of the bladder (Fig. 680). *Enterocoele* is a hernia of the cul-de-sac with

its intestinal contents (Fig. 679). *Rectocele* is a hernia of the rectum (Fig. 681).

**General Discussion**—The bony pelvis is closed by a diaphragm consisting of the levator ani and coccygeus muscles with a strong layer of fascia above and below. This diaphragm is pierced anteriorly by the vaginal canal and urethra. Reinforcing the diaphragm below is the triangular ligament which extends from one pubic ramus to the other. The uterus, bladder and rectum are retained in normal position by strong elastic bands of connective tissue and muscle. The pelvic diaphragm does not support the uterus but counteracts the strain of intra-abdominal pressure. The round and uterosacral ligaments act mainly in tilting the uterus forward.

**Etiology**—Prolapse of the uterus and its associated lesions are usually due to childbirth injury and occur most commonly in women who have had a number of children or difficult labors. In nulliparous women prolapse is usually the result of a congenital defect of the tissues. Coughing or straining predisposes to these lesions. Changes which occur in the tissues in advanced age also favor prolapse.

**Pathology**—Labor and childbirth subject the muscular, fascial and connective tissue structures of the pelvis to various types of injuries. Thus *urethrocele* results from injury to the supporting structures which normally surround the urethra. *Cystocele* occurs because of injury to the pubocervical fascia causing it to become thinned and to spread laterally. It is most commonly associated with prolapse of the uterus for the position of the bladder depends to a great extent on the position of the cervix. *Cystocele* varies from slight to complete herniation of the entire bladder. Retention of urine occurs if the hernial sac is below the level of the urethra. *Prolapse of the uterus* results from relaxation of the uterine supports particularly of the broad ligaments. The prolapse is *incomplete* if it remains within the vagina or *complete* if it protrudes beyond the introitus. Prolapse is usually preceded by retroversion of the uterus then being forced downward by the intra-abdominal pressure. The vaginal canal is commonly dilated and the perineum relaxed. Elongation of the cervix is often an asso-

erated condition. Ulceration of the mucous membrane of the protruding vagina and cervical erosions are frequent. The cul-de-sac may descend with the cervix dissecting its way downward between the rectum and the posterior vaginal wall forming an *enterocele*. Hernia of the rectum having its origin above the perineal body is often seen. This is known as a *high rectocele* and is due to separation of the perirectal fascia. *Low rectocele* occurs when the perineal body is injured so as to cause the rectum to bulge into the vaginal opening (Fig. 681).

**Symptomatology.**—Most patients com-

of difficult labors with symptoms which are usually characteristic. Examination of the



Fig. 67.—Prolapse of the uterus with (a) cystocele and (b) enterocele.

plain of a bearing down pain, a feeling of weight in the pelvis and lumbosacral back ache. Others complain only of the protruding mass, particularly when standing on their feet. If urethrocele is associated there is often incontinence of urine. In cystocele residual urine causes irritation of the bladder resulting in urinary frequency. Inability to start the flow of urine without first replacing the protruding part is the complaint of many. Difficulty in defecation is common when rectocele is present. Leukorrhea occurs when erosion of the cervix or vaginal walls exists.

**Diagnosis.**—The diagnosis of prolapse of the uterus and its associated pathology is made without difficulty. There is a history

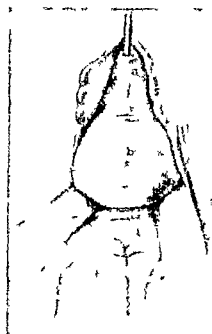


Fig. 68.—a. Cystocele. b. cystocele associated with incomplete prolapse. (A sound has been inserted in the bladder.)

patient in the erect posture is of value. In cystocele the presence of residual urine is diagnostic. Cystoscopy aids in differential



Fig. 68.—a. Rectocele with finger inserted in rectum to demonstrate the hernial sac.

ing such conditions as a stone or other lesions of the bladder.

**Treatment**—(A) *Preventive* measures include (1) the proper conduct of labor prohibiting expulsive force before cervical dilation (2) episiotomy to prevent extensive perineal injuries (3) immediate perineal repair following labor (4) adequate puerperal rest and (5) examination six weeks after delivery and if retroversion has occurred replacement and support by means of a pessary until involution is complete (B) *Palliative* measures rest in bed and replacement of the uterus until congestion has subsided and ulcers and erosions have healed support when possible by properly fitted pessaries (C) *Curative* measures Surgical treatment is employed (1) in child bearing women with cystocele and prolapse of the uterus the bladder is advanced then the pubocervical fascia is reunited and the anterior vaginal wall is

reconstructed (Fig 682 b) In complete prolapse vaginal hysterectomy (Vino) is employed when the uterus is atrophic In this operation the remaining broad ligaments are united in the midline forming a hammock on which the bladder rests This is followed by perineorrhaphy (Fig 682 c) Incontinence of urine is best controlled by uniting the relaxed sphincter muscle of the bladder in the midline with mattress sutures (Kelly)

Other surgical procedures recommended for prolapse are anterior colporrhaphy with amputation of the cervix and reconstruction according to the technic of the Manchester operation The perineum must also be reconstructed

For elderly women with extreme prolapse in whom marital relationship is no longer a factor the La Forte procedure gives excellent

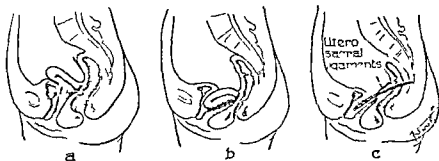


Fig 682—Lateral view showing principles of operative procedure advised in cystocele and prolapse a Advancement of bladder b interposition operation c vaginal hysterectomy

sutured to the cervix from the internal os down thereby closing the hernial opening (Fig 682 a) The cervix may then be amputated and shortening of the cardinal ligaments employed to raise the prolapsed uterus This is followed by perineal repair In incomplete prolapse this may be all that is necessary If after these procedures the fundus does not remain forward intra-abdominal shortening of the round and utero-ovarian ligaments will place the uterus in normal physiologic position (2) In non-child bearing women surgical correction depends on the degree of prolapse and the size of the fundus In incomplete prolapse the interposition operation (Watkins) is indicated when the uterus has not atrophied and cystocele is the outstanding finding It consists of interposing the fundus of the uterus between the bladder and the anterior vaginal wall The perineum should be

results This consists of triangular denudation of the anterior and posterior vaginal walls from the cervix downward to the vaginal orifice and uniting of the same from above downward thus retaining the prolapsed organs within the vagina

#### PERINEAL LACERATIONS AND RELAXATIONS

The important structures making up the perineal body are the two pubococcygeus columns of the levator ani muscle running from the pubis above along either side of the vagina and inserting in the sides of the rectum and the anococcygeal ligament Reinforcing these muscles below is the triangular ligament a fascial floor extending from one pubic ramus to the other The function of the perineal body is to guard the vaginal opening

Injuries of the perineum occur most frequently as a result of childbirth and are due to marked stretching or lacerations. Such lacerations may be superficial or deep in complete when involving the perineal body.

Operations devised to repair perineal lacerations and relaxations require submucous exposure of the structures which compose this body and reconstruction. A modified Hegar's operation in which the bellies of

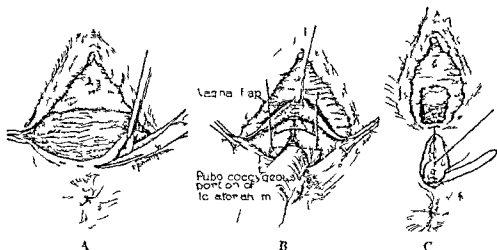


Fig. 683.—The three steps that are taken in the repair of a simple laceration of the perineum. A First step: Making the incision on the vaginal floor at the mucocutaneous junction. B Second step: Inserting the levator muscle between the rectum and vaginal floor, held by uniting the triangular ligament in the midline. C Third step: Closure with a subcuticular suture.

alone or complete when the tear extends into the rectum. The injury may occur in the midline or extend into the vaginal sulcus in which case the structures supporting the rectum are injured and result in the formation

of the pubococcygeus muscle and the triangular ligament are united in the midline, is a satisfactory procedure. Complete lacerations re-

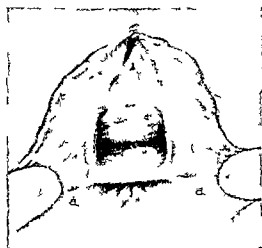


Fig. 684.—Complete laceration of the perineum with sphincter palsy.

of rectocele and predispose to a prolapse of the anterior vaginal wall with resulting cystocele (Fig. 681). Perineal tears extending into the rectum cause rupture of the sphincter ani muscle and loss of sphincter control with incontinence of feces (Fig. 684).

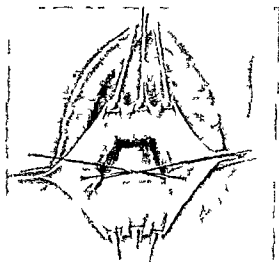


Fig. 685.—A method of repair of complete laceration. Sutures have been placed in the torn ends of the sphincter ani muscle.

quire that the ends of the sphincter ani muscle be reunited in the midline previous to the reconstruction of the perineal body (Fig. 685).

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## DISTURBANCES OF MENSTRUATION

## UTERINE HEMORRHAGE

**Menorrhagia**—In most cases menorrhagia is caused by lesions of the organs concerned with menstruation viz the uterus the ovaries and the controlling glands of internal secretion. The most important glands of internal secretion that modify the menstrual function in this way are the ovaries pituitary and thyroid. This type of menorrhagia is called functional menorrhagia and thyroid extract is often effective in its cure. Some of the newer gonadotropins offer promise in control of the bleeding. Anovulatory bleeding may take the form of menorrhagia or metrorrhagia.

Local lesions which cause menorrhagia are fibromyomas pelvic and vaginal inflammations hyperplasia of the endometrium polyp carcinoma of the corpus uteri endometriosis sarcoma and ovarian neoplasms. These lesions may also produce metrorrhagia but usually only when they are complicated with degenerative changes torsion or infection.

**Metrorrhagia**—Metrorrhagia is irregular because it is not a result of rhythmic changes of the menstrual cycle. Blood loss of this type is usually the result of actual damage to the vascular system of the pelvis by trauma necrosis or infection. Examples of this form of bleeding are contact bleeding in carcinoma of the cervix irregular spotting from a necrotic myoma a disturbed intrauterine or ectopic pregnancy and bleeding associated with pelvic infections.

Sudden profuse hemorrhage occurring in a patient who has been menstruating regularly is almost pathognomonic of a disturbed pregnancy.

Metrorrhagia may be caused by carcinoma anywhere in the genital tract but especially in the cervix cervical lesions ectopic pregnancy and ulcerations of the vagina. Metrorrhagia is abnormal and demands attention. Profuse or irregular bleeding calls for diagnostic curettage and biopsy.

## AMENORRHEA

Amenorrhea means absence or cessation of menstruation. It may be physiologic or pathologic. Physiologic amenorrhea occurs before puberty during pregnancy or lactation and following the menopause. Uterine bleeding during these periods is abnormal. Amenorrhea during lactation lasts normally for from six weeks to four months. If it lasts longer another pregnancy may be suspected.

Menstruation usually begins between the eleventh and sixteenth years. Irregularity of the interval and duration of the flow are quite common and should not cause concern unless too pronounced. Delayed puberty may be due to hypoplasia of the genital organs. The amenorrhea which occurs in atresia of the genital tract is not a true amenorrhea but a retention of secretion and treatment of the stenosis will establish the normal rhythm. Replacement therapy with those hormones which stimulate the müllerian tract in certain cases is known to have the power to overcome some of the minor degrees of hypoplasia.

After the menstrual habit is once established any period of amenorrhea indicates pregnancy. Error will be avoided if this is assumed until disproved. The recently developed tests for pregnancy are very accurate and should be used more frequently.

The normal menopause is characterized by complete and permanent amenorrhea. Later bleeding should be regarded with suspicion.

Castration either surgical or by irradiation produces amenorrhea. Diabetes psychoses tuberculosis syphilis and morphinism may cause amenorrhea. Functional amenorrhea may be produced by a fear of pregnancy or by any marked emotional disturbance. A marked change in climate also may cause amenorrhea.

## RELATIONSHIP OF THE GLANDS OF INTERNAL SECRETION TO GYNECOLOGY

The glands of internal secretion are important in the physiology of the female organism. Knowledge in this field increases rapidly and necessitates the frequent revision of ideas.

Among the most important effects are the pituitary, ovarian and thyroid. Cyclic changes are produced which are necessary for reproduction.

Investigation indicates that the pituitary gland is the initiator of this cyclic process. Hypophysial hormones largely from the an-

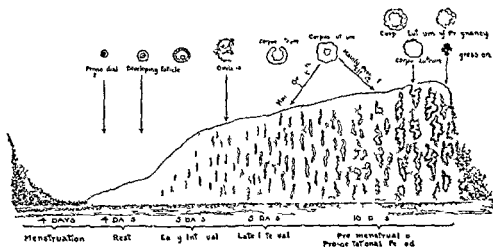


Fig. 686.—Diagram illustrating the menstrual cycle with its four phases.

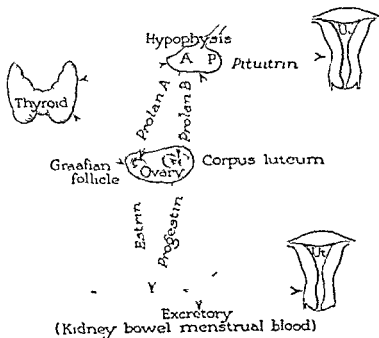


Fig. 68.—Schematic drawing to illustrate the interrelationships between the various glands taking part in the cyclic changes of the pelvic organs. The arrows indicate action in both directions. When the excretory level is reached a rest mutation of the motor (pelvic) system occurs and a new cycle is initiated. The resultant phases in the uterine mucosa are shown in figure 686. (After Moore.)

All the glands of internal secretion by their reciprocal action play a role in the physiology of the female reproductive system. Secretions from any one of the glands may stimulate or depress the other members of the endocrine system. The gland produc-

terior lobe stimulate the gonads. Ovarian is an excretory (gametogenic) and a secretory (endocrine) function. During the ripening of the egg the growing follicle pro-

\* Mazer and Colditz. Clinical Gynecology of the Female. Charles C. Thomas Publisher.

duces a hormone called estrin (folliculin female sex hormone). This hormone acts on the uterus and vagina producing the changes found in the first half of the menstrual cycle. The activity in the endometrium is intensified and completed by another ovarian hormone, progesterin. Progesterin is produced in the corpus luteum. Its action is necessary for the preparation of the field for the implantation and early growth of the fertilized ovum.

The gradual increase in concentration of one or both of these hormones in the blood depresses the gonadal stimulating activity of the pituitary. Further ovulation does not occur until the stimulation threshold is again reached by excretion of sufficient quantities of hormone. At this time the pituitary again comes into the secretory phase and the cycle (Fig. 687) is repeated.

The secretion of the posterior lobe of the pituitary is called pituitrin. It has been divided into two active principles, oxytocin and vasopressin. Oxytocin produces contraction of the uterine muscle. Vasopressin possesses the three remaining functions of the posterior lobe: (a) an antidiuretic effect, (b) stimulation of gastrointestinal peristalsis and (c) the pressor-depressor effect.

### DYSMENORRHEA

Dysmenorrhea may be classified as follows: (1) essential or primary dysmenorrhea and (2) acquired dysmenorrhea. Women who have suffered since the beginning of menstrual life constitute the essential or primary group, while those who later acquire pain comprise the second group. The acquired type may be engrafted on the essential form, but a carefully taken history will help to distinguish them.

**Cause.**—The cause of pain in the primary dysmenorrheas and in a few of the acquired types is not well understood. Recent investigation indicates that it is due to a disturbed physiology and consequent abnormal motility of the müllerian tract. Hormonal balance is essential to the normal function of the pelvic organs. Defects in development ranging from complete stenosis of the genital tract to mild degrees of infantilism may produce an essential dysmenorrhea. Congenital malpositions of the uterus may be associated with dysmenorrhea. Hypoplasia with lack

of adjustment to the changes in size and tension during the menstrual cycle offers a more rational explanation of pain than malposition, especially as surgical reposition often fails to give relief. Interference with the outflow of menstrual blood through the cervix, especially in a patient who has a long conical cervix with a very small canal, must still be considered, since about half of the patients with primary dysmenorrhea are relieved by dilation. More recent investigations may indicate that the relief of pain may be due largely to the mechanical effects of the surgical treatment which change the endocrine balance.

Common causes of acquired dysmenorrhea are pelvic inflammations, fibromyomas, especially of the intrauterine type, endometriosis, hyperplasia of the endometrium, polyps, acquired malpositions of the uterus, cervical erosions, ovarian neoplasms and psychic or debilitating diseases.

**Treatment.**—The treatment of essential dysmenorrhea is often unsatisfactory since the cause is not known. Analgesics or antispasmodics such as atropine may suffice until a change of hormonal status is caused by marriage or pregnancy. Recent reports indicate that replacement hormonal therapy may eventually solve many of these problems.

Dilation of the cervix will relieve about one half of these patients. Some of the remainder obtain partial relief. Mutilating operations on the cervix such as wedge-shaped excisions, dissection and tearing with mechanical dilators are contraindicated. Operations for the correction of retrodisplacement are seldom indicated and should be employed only after other treatment has failed.

Since any disease which increases pelvic congestion or produces an abnormal growth in the pelvis may cause acquired dysmenorrhea, the treatment varies with the underlying pathologic condition. Conservatism is essential because the patients are young women. Medical management will cure most of the inflammations. Myomectomy may save a fibromatous uterus. Conservative surgery rather than surgical or radical castration is advised for endometriosis. If a properly fitted pessary gives relief, then the patient may be relieved by a retrodisplacement operation.



**Membranous Dysmenorrhea**—Membranous dysmenorrhea is so termed because the endometrium is shed *en bloc* or as large shreds at each period. Expulsion of these casts of the uterus produces pain similar to that of abortion. The explanation for this desquamation is not clear but it probably is an abnormal reaction of the endometrium to its hormonal stimuli. However in some cases previous postabortive uterine infection seems to play an important role. Treatment as yet is repeated premenstrual curettage followed by the application of tincture of iodine to the uterine cavity. These patients are usually sterile and vaginal hysterectomy may be performed if the condition is severe.

### MENOPAUSE

The climacteric or menopause denotes the cessation of menstruation. Most women reach the menopause between forty and fifty years of age. A smaller number continue to menstruate after fifty. Cessation before forty years of age is due usually to derangement of other glands of internal secretion rather than to a running down of the glandular mechanism.

The onset may be abrupt but more often is gradual and characterized by a decrease of menstrual flow and a lengthening of the interval between periods. Often nervous instability appears causing the so called hot and cold flashes, attacks of vertigo, ringing in the ears, headache and palpitation. Irregular bleeding, however slight, after the menopause raises the question of a malignant growth.

Changes in the pelvis are more constant and marked. Cessation of cyclic stimulation causes progressive atrophy, the ovaries become sclerotic and shrunken, the uterus and its supporting structures lose their tone and become smaller and a loss of support causes the uterus to assume a backward position and to sag downward. The fallopian tubes become straight and attenuated, the cervix shrinks until it may be almost flush with the vaginal vault, the latter becomes more conical and later adhesions of the cervix or vaginal walls may appear. The vagina loses its former elasticity and becomes smooth and rigid. This process of atrophy extends also to the external genitals.

**Treatment**—Treatment of the meno-

pause may be general or local. General treatment is directed toward stabilizing the disturbed nervous system. A strict schedule including adequate fresh air and sunshine, high vitamin intake, the use of sedatives such as bromides or the barbiturates and the avoidance of fatigue is beneficial. Substitution therapy with a potent product of the female sex hormone in most cases will produce satisfactory results. Local treatment includes examination at intervals of six months. Short intensive courses of estrogenic therapy given hypodermically may afford lasting relief. If symptoms recur, estrogens by mouth in interrupted series are often sufficient. Minimal dosages should be adhered to as over dosage frequently causes postmenopausal uterine bleeding. Investigation of irregular bleeding or unusual secretion, maintenance of normal drainage from the cervix and vaginal canal and correction of areas of chronic inflammation such as erosions of the cervix are essential.

### STERILITY

Sterility occurs in from 8 to 15 per cent of marriages and therefore is an important problem. Diagnosis may require the united efforts of the gynecologist, urologist and endocrinologist.

*Primary sterility* denotes failure to conceive under normal conditions in from two to five years. Failure of conception in a patient who has previously borne a child is called *secondary sterility*.

Sterility may be further divided into two groups. Absolute sterility means that impregnation is impossible; often a developmental defect of the pelvic organs is present. A larger group form the class of relative sterilities. These embrace those conditions which make pregnancy not impossible but difficult. In such cases the best results are obtained.

In studying sterility it must be remembered that the fault in one third or one half of these cases may lie with the husband and he should be examined before treatment of the wife is begun. Conditions which affect male reproductive power are inflammations such as gonorrhea and tuberculosis, metabolic diseases, psychic disturbances, developmental defects, drug addiction and chronic alcoholism. Important causes of female ster-

ility are pelvic inflammations especially of the cervix and fallopian tubes gonorrhea postabortive infections acute appendicitis and tuberculosis Metabolic diseases and dysfunction of the thyroid pituitary and ovaries are also frequent New growths such as fibromyomas ovarian tumors and endometriosis may interfere with conception

**Diagnosis**—Diagnosis of the cause of sterility is usually a process of elimination which should follow an accurate plan The first step is a history of both husband and wife noting duration of sterility use of contraceptives sexual compatibility general health and previous infections or operations This is followed by a physical examination of both partners Attention should be paid to stigmas of hypoplasia infection glandular dysfunction and psychic disturbances It is usually necessary to include complete microscopic study of the semen insufflation or occasionally visualization of the tubes and the usual blood tests including the Wassermann test and a differential count

**Treatment**—The indiscriminate use of tubal insufflation and particularly the injection of an opaque medium for purposes of visualization are deprecated Relative sterility may be made absolute by the unintelligent use of these procedures They should never be performed in the presence of infection or bleeding The ideal time is about one week after the menstrual period and then should be carried out under aseptic conditions

Improvement of the general health a liberal high vitamin diet a sensible sex regime or hormonal therapy such as thyroid medication will often suffice Cruterization affords a simple method of treating infections of the cervix Careful diagnosis and treatment of the vaginal infections especially those due to trichomonas vaginalis and yeast will restore the important normal vaginal acidity Infections in the pelvis proper do not lend themselves to such active treatment but many of them will improve functionally under conservative treatment Artificial insemination is not recommended because of the risk of infection

Indications for the surgical relief of sterility should be very clear Dilatation of the cervix often proves beneficial and is relatively safe Amputation and repair (trachel

orrhaphy) require an expert technique otherwise a relative sterility may become absolute Early habitual abortion may follow A retrodisplacement operation is not indicated unless the necessity for it has been shown by the use of a pessary Myomectomy should be performed only after other methods have failed and when the tumor does not encroach on the uterine cavity Conservation of as much normal ovarian tissue as possible is essential

The results of autotransplantation or heterotransplantation have not been sufficiently successful to warrant their general use Operative restoration of tubal patency becomes more promising in view of recent work These operations should be undertaken only after the patient has been told of the infrequency of cure and only by someone who is entirely familiar with the detailed technique

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## ECTOPIC PREGNANCY

Ectopic or extrauterine pregnancy exists when the implantation of the fertilized ovum occurs anywhere outside the uterine cavity. Most ectopic gestations are found in the fallopian tube chiefly in the ampulla some times in the isthmus rarely in the interstitial tube and only very seldom in the ovary and most infrequently in the abdominal cavity (Figs 688 and 689). It may occur as often as once in 300 or 400 pregnancies.

**Etiology**—The cause may be anything which retards the progress of the fertilized ovum toward the uterus thus permitting it to reach the trophoblastic stage of development when it has the power of implantation wherever it may be. The cause may be in the ovum or the tubes.

**Causes Due to the Ovum**—The ovum may be too large to traverse the tube because of the adhering membrana granulosa or rapid cell division or growth during the interval of transmigration.

**Causes in the Tube**—Formerly inflammation was considered the chief cause of tubal adnation but now it is considered more or less accidental and really depends more upon the location of the ovum when the trophoblast becomes capable of producing implantation (W Blair Bell). Although the etiologic role of pelvic infection has been overestimated salpingitis is a factor because of destruction of cilia or adhesions of tubal folds forming pockets and strictures. Likewise perisalpingitis may cause external adhesions kinks narrowing of the tube lumen and interference with peristalsis. Tubal diverticula accessory ostia ending in blind sacs tortuous infantile tubes double narrow lumina or tumors which distort or constrict the tube may favor tubal nidation.

**Pathology**—The ovum erodes its way into its ectopic location exactly as it does into the endometrium but the results are inevitably pathologic because the fallopian

tube or any other site is completely unsuited anatomically and histologically for the reception or development of the conceptus.

**Decidua**—There is no true decidua although there is usually a 'decidual reaction' in the form of decidual patches islands and isolated cells.

**The Basalis**—Because there is no protecting true decidua at the site of nidation the ovum almost immediately erodes its way directly into the muscularis thus weakening the tube wall literally riddling and weakening the muscular layers and opening relatively large vessels. The resulting hemorrhage overfills the intervillous spaces frequently crushing the villi into tangled masses. Often the capsule is so distended that it ruptures.

**The Capsularis**—At first the ovum is entirely intramuscular. As it grows it bulges



Fig 688—Tubal pregnancy ampullar implantation. The tube wall is unruptured. Beginning internal rupture (tubal abortion) noted by small amount of blood in the abdomen.

into the lumen of the tube pushing the surrounding muscle wall and mucous membrane before it and producing a false capsularis. This pseudocapsularis soon comes in contact with the opposite tube wall which then bulges away from the site of implantation (Figs 688 and 689). There is no true decidua in this pseudocapsularis although decidual cells and islands of decidua are more often found than in the pseudobasalis. Villi at



Fig. 689—Ampullary pregnancy; the tube wall is unruptured. Frank internal rupture is indicated by the protrusion of a blood clot from the ostium abnormale and considerable blood in the abdomen.\*

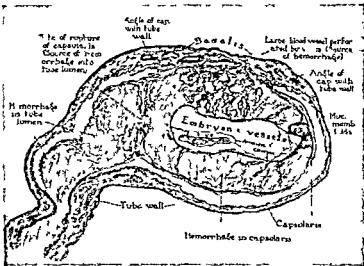


Fig. 690—Composite drawing of various serial sections brought to one level showing rupture through the capsular wall with blood flowing through the tube. The ovum is still firmly attached to the tube wall showing that the bleeding is from an internal rupture and is not a tubal abortion.\*

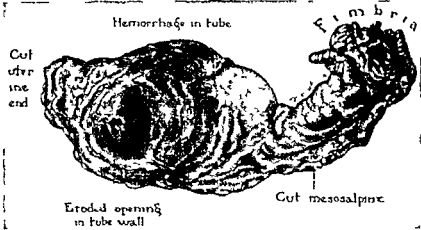


Fig. 691—Istulae implantation, so-called rupture, but there is only a small eroded hole. Note the eroded blood vessel, which caused a large hemorrhage.\*

\* Nelson's Loose-Leaf Surgery, Thomas Nelson and Sons, Publishers

tracking the vessels of the tube are seen in figure 690

**Tubal Rupture and Abortion**—Rupture may occur externally through the tube wall into the abdominal cavity or internally through the pseudocapsularis into the tube lumen commonly called tubal abortion. The writer has been able to demonstrate the bursting of the inner capsule (Fig 690) in every specimen of so called tubal abortion that he has examined microscopically in serial sections. Therefore he prefers the term internal rupture to tubal abortion.

When not ruptured through the tubal wall the pregnancy is often erroneously said to be unruptured even when blood is found in the abdomen. If there is blood in the peritoneal cavity a pregnant tube is always ruptured either internally or externally.

An ovum protruding through the ostium abdominale of the tube is according to this writer's observation not usually due to expulsion by muscular action of the tube but more often due to implantation of the ovum so near to the fimbriated extremity that it grows in the direction of least resistance—out through the end of the tube.

**Changes in the Uterus**—The uterus is enlarged and softened and decidua is formed in the uterine cavity in every case of ectopic pregnancy. The decidua persists until the death of the ovum then it degenerates bleeds (the source of the characteristic vaginal bleeding) and is cast off in debris patches of decidua or a cast of the uterine cavity.

As soon as the ovum dies the endometrium begins to regenerate and resumes its cyclic changes often even before the pregnancy is terminated. As long as living villi persist genital bleeding continues.

Ectopic pregnancy recur in the remaining tube in from 10 to 15 per cent of cases. Twin ectopic pregnancy exists when there are two embryos in one tube one in each tube or one in a tube and another in the uterus.

**Diagnosis**—While amenorrhea is presumptive evidence of normal pregnancy delayed protracted or otherwise abnormal menses are suggestive of ectopic pregnancy especially when accompanied by anomalous vaginal bleeding pain fever leukocytosis and a mass to one side or behind the uterus.

The symptoms vary with the time the patient is first seen before during or after rupture.

**Diagnosis before Rupture**—Vaginal bleeding and pain are rare before rupture although there may be mild cramps but usually only discomfort soreness or indefinite distress. At this time there is no abdominal bleeding therefore no consequent fever or leukocytosis is noted. Before rupture because the ovum is usually alive the Aschheim Zondek test (or one of its modifications) is valuable.

The usual signs of pregnancy are not marked and subjective and objective symptoms are so elusive that definite diagnosis is difficult. The intradermal injection of colostrum (the Fall test) may prove to be quite as valuable as the rabbit test.

**Diagnosis during Rupture**—This is the most important period in the clinical course because the diagnosis missed before rupture may now be corrected and the impending tragedy of frank rupture may be avoided by a timely operation.

Fortunately the signs and symptoms are more definite pain the most constant subjective symptom is sharp lancinating and definitely on one side of the pelvis. Flaccidations of pain followed by temporary or complete relief are particularly significant.

The cervix is exceedingly sensitive to movement of the examining finger. Vaginal bleeding may be constant or intermittent dribbling or spotting rarely is it profuse and clotted usually it is brownish red. Abdominal bleeding recurs or increases with each paroxysm of pain and is always accompanied by fever and leukocytosis.

Ectopic pregnancy must always be kept in mind when dealing with an acute abdomen.

When examination is made under anes the is the utmost gentleness is imperative otherwise the pregnant tube may be ruptured.

**Diagnosis after Rupture**—If diagnosis is delayed until after rupture a serious error has been made. One should not wait the agonizing pain on one side accompanied by violent internal hemorrhage followed by nausea vomiting rapid feeble pulse cold sweating pallid skin shallow breathing air hunger restlessness and extreme anxiety.

Over the side of the ruptured tube there is excessive tenderness and rigidity sometimes the whole abdomen is distended and tender a bluish black discoloration about the navel (Cullen's sign) indicating extensive abdominal hemorrhage may be present.

**Differential Diagnosis**—The principal conditions to be differentiated are uterine abortion, pelvic infection, appendicitis or any acute abdomen.

**Abortion**—Abortion shows profuse bleeding with clots the pain is intermittent cramplike and progressively increasing. Parts of the embryo or villi in the vaginal discharge render the diagnosis of abortion certain. Ectopic pregnancy is more likely when

matory disease. If puncture of the vaginal vault shows blood an ectopic pregnancy is present.

**Other Conditions**—Other acute abdominal conditions such as an ovarian cyst with twisted pedicle or a ruptured gastric ulcer will seldom need differentiation from ectopic gestation. The history or results of biologic tests for pregnancy will usually make the diagnosis definite.

**Summary**—When a woman has a skipped, delayed, prolonged or otherwise anomalous menstruation a bloody dribbling brownish red discharge accompanied by cramps sudden sharp stabbing pains recurring on one side of the pelvis and an enlarged soft

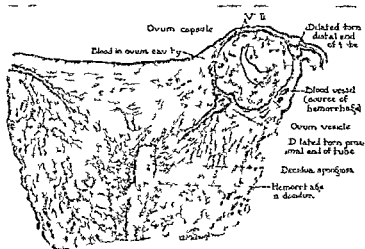


Fig. 692.—Composite transverse section of an interstitial pregnancy brought by the artist to one plane. Note particularly the true decidua in the uterus, the funnels at the two torn ends of the interstitial tube, the complete tracing of the intramural tube from the uterine cavity to the isthmus and the hemorrhage in the ovum capsule and the uterine decidua.

there is a bulging cul-de-sac with leukocytosis and a normal sedimentation rate which is decreased in ectopic gestation. A diagnosis of ectopic gestation is quite certain when there is moderate fever, leukocytosis, great pain on moving the cervix and an exquisitely tender pulsating mass behind or to one side of the uterus.

**Pelvic Infection**—In inflammatory disease there may be a history of gonorrhea with positive smears or postabortal infection but there are no subjective signs of pregnancy. Biologic tests for pregnancy are negative and there is no vaginal bleeding or menstrual abnormality. In ectopic pregnancy the uterus is enlarged and leukocytosis is constant but likely to be higher in inflam-

utery disease. If puncture of the vaginal vault shows blood an ectopic pregnancy is present. If there is an exquisitely tender mass at one side or back of the uterus and if there is moderate fever and leukocytosis a diagnosis of tubal pregnancy is justifiable.

**X-Ray Diagnosis**—In early cases uterine salpingography with iodized oil may reveal a defect at the site of implantation. Biologic pregnancy tests will only be positive when the ovum is alive.

**Interstitial Tubal Gestation**—Implantation in the intramural tube differs from gestation in the free tube only because of the

• Nelson's Loose-Leaf Surgery. Thomas Nelson and Sons, Publishers.

differing anatomical conditions which modify its progress e.g. the interstitial tube has little muscular wall hence the ovum almost immediately becomes embedded in the uterine wall which resists rupture much longer than the free tube but it rarely avoids rupture beyond the sixth month of gestation when there is violent pain and bleeding. If a soft mass is felt at one uterine cornu with the usual characteristic history of ectopic pregnancy the diagnosis of interstitial pregnancy is justifiable.

**Ovarian Pregnancy**—Formerly it was believed that ovarian implantation occurred only in the burst follicle. Further investigation (Stux and Gertsch) proved that nidation occurs in the following ovarian locations:

- 1 *Intrafollicular* the most common
- 2 *Superficial* Rarely nidation may occur on the ovarian surface because of furrows sulci or superficial endometriosis
- 3 *Suprafollicular* also rare. A blood clot holds the ovum at the opening of the burst follicle where it is fertilized becomes implanted and develops
- 4 *Interstitial* exceedingly rare. Theoretically the ripe follicle bursts inward because of a tough capsule when it finally ruptures outward the spermatozoon fertilizes it in the interstitial part of the ovary where it develops

A hematoma of the ovary frequently is due to an ovarian pregnancy but may be due to a ruptured lateral cyst leukemia phosphorus poisoning acute torsion or endometriosis. The symptoms are essentially the same as in tubal pregnancy for which it is usually mistaken.

**Abdominal Pregnancy**—*Primary*—Although the possibility of primary implantation into the peritoneum has long been denied enough authentic cases have been reported to prove this bizarre possibility.

*Secondary*—This happens when a live embryo escapes from its primary location into the abdominal cavity the placenta retains its original attachment and the fetus continues to develop sometimes even reaching full term. Operation at full term may yield a living child which is frequently de-

formed. When the condition is not recognized at full term a short false labor occurs the fetal circulation stops and the placenta degenerates and is often completely absorbed.

There is much discomfort fetal movements are more active and the fetal heart tones funic souffle and uterine bruit are more distinct. The fetus seems to be directly under the abdominal wall with the uterus to one side of it. While the fetus may survive it usually dies long before term and degenerates by maceration adipocere or lithopedion formation.

#### **Treatment of Extrauterine Pregnancy**

—There is no justification for expectant treatment of ectopic pregnancy. Too many patients die while the physician waits for recovery from shock which may never transpire. Even in the presence of shock due to hemorrhage very few patients die as a result of immediate operation by one skilled in the procedure. The Jussieu failure policy is most hazardous. Those who advocate awaiting recovery from shock lose precious time and more precious blood. There can be no safety until the bleeding vessels are tied. Immediate operation does not mean ill timed hurry but a deliberate rapid preparation for operation under as favorable conditions as possible. Simultaneously shock must be combated by rest morphine and dried blood plasma given slowly.

*Before rupture* the prompt removal of the gestation is urgently indicated. The ease and good results of this procedure emphasize the necessity for early diagnosis and prompt operation.

*During rupture* there is blood in the peritoneal cavity and consequent fever leukocytosis and pain catastrophe impends though the tube has not yet burst. Immediate operation is imperative to avoid further bleeding shock and collapse.

After rupture when there is often collapse due to alarming hemorrhage there is no assured safety until the bleeding artery is tied. Transfusion of blood has been one of the greatest factors in limiting mortality in ectopic pregnancy. Unfortunately in smaller communities blood donors or blood banks are often not readily available.

The development of the preparation of

dried blood plasma and its extensive and successful use with our wounded soldiers opens up additional resources for the treatment of these hemorrhagic tragedies in civil life. The smallest hospital now has available life saving plasma which requires no blood grouping and can be easily and quickly given to tide over any emergency at least until a transfusion can be given. Any hospital or physician can now have a plasma bank.

**Operative Technique**—Only such blood as may interfere with exposure of the source of the bleeding should be removed; then hemostasis is secured by means of clamps or digital pressure followed by secure ligation. The ovary should be quickly isolated so that it will not be removed with the tube.

The removal of the entire tube with a wedge of the uterine horn will prevent a second ectopic implantation in the stump of the removed tube, several cases of which have been reported. All blood should be left in the abdomen as it will be absorbed rapidly to the great benefit of the patient and will not cause adhesions.

In early interstitial pregnancy the mass may be removed from the uterus but in more advanced cases hysterectomy may be necessary.

**Treatment of Abdominal Pregnancy**—When the fetus is alive and the mother is in good condition laparotomy may be postponed until the thirty eighth week in the interest of the fetus. Although it may be deformed a sufficient number are normal to warrant delay.

The treatment of the placenta is most important because of danger of hemorrhage. If the fetus has been dead for sufficient time the uterine sinuses are already thrombosed so that the placenta may usually be removed without causing alarming bleeding. If however fetal death is quite recent or the fetus is alive at the time of operation it is exceedingly dangerous to attempt to remove the placenta because of the danger of excessive bleeding. If one feels sure that there is no infection Beck advises tying the cord short and cutting it leaving the placenta and closing the abdomen without drainage. By an older method if one is not sure of asepsis the membranes may be sutured to the abdominal wall the cavity

loosely packed with gauze and the placenta permitted to drain away slowly.

**Mortality**—Modern scientific methods have reduced the mortality of ectopic pregnancy from around 90 per cent before Lawson Tait's first operation to 2 or 3 per cent. In a series of 1421 reports of cases collected by the writer from six teaching clinics the mortality was only 2.24 per cent. Ectopic pregnancy is a potential hemorrhagic catastrophe which nearly always without proper treatment kills the child and is also a tragedy for the mother. To have reduced the death rate so remarkably is a tribute to improved diagnosis to modern clinical and laboratory methods and to gynecological judgment and skill.

JENNINGS CRAWFORD LITZENBERG

## ENDOMETRIOSIS

The term endometriosis was suggested by Simpson to designate a variety of adenomatous lesions found in the female pelvis which present histologic and functional characteristics of normal endometrium. It may be truly called a disease of theories for more suggestions as to the origin of these islands of ectopic endometrium have been offered than for almost any other phase of pelvic pathology. Cullen gave the first definite clue as to the true significance of their origin when he proved that the glandular phases of adenomyomas were derived from the endometrium. The earlier authorities attributed them to adult remains of the wolfian system, inclusions of müllerian rests, the influence of inflammation on the endothelial cells of the peritoneum causing them to be transformed into cuboidal or cylindrical cells and metaplasia or the effect of inflammation by which the cuboidal cells of the germinal epithelium are transformed into cylindrical epithelium which resembles mucosa. The implantation theory recently proposed by Simpson is now more widely accepted than any of the earlier theories. Sampson evolved his theory after an exhaustive study of perforating hemorrhagic cysts of the ovary and proved that misplaced endometrial tissue wherever found is a histologic structure identical with that of uterine mucosa and is governed by the same physiologic factors as the mucosa of the



uterus. Uterine or tubal epithelium may escape into the peritoneal cavity during menstruation and these regurgitated fragments spill into the pelvic cavity, lodge on the various structures (having a special predilection for the ovaries), become implanted and eventually develop into adenomatous growths that respond to the stimulus of the ex hormones as does the normal endometrium. These adenomatous islands may develop into hematomas filled with menstrual blood or they may remain as small super-

the myometrium by endometrium is seen fairly frequently. It occurs usually in the middle-aged women and often is the cause of menorrhagia. The uterus may be a little enlarged, the enlargement usually involving the posterior wall. Treatment is surgical.

Simpson's conclusions are still the subject of much controversy, but there is no doubt that he has proved the definite origin of a large group of ectopic endometrial lesions not explained by any other theory and has at least proved the identity and physiologic

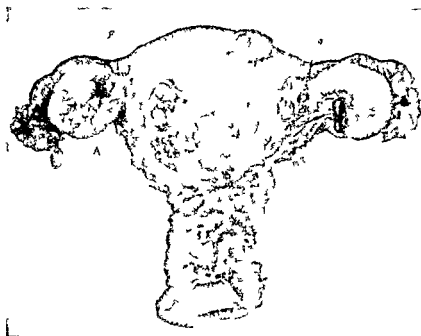


Fig 693.—Perforation menorrhagic at both ovaries. Adenomyomas of the posterior wall of the uterus. Posterior view of the uterus, tubes and ovaries (natural size). At operation both ovaries were adherent to the posterior surface of the uterus. The left ovary is partially collapsed owing to the escape of the contents of the cyst. The raw area with perforation in the center is shown. The contents of the hematoma of the right ovary were thicker than those of the left and are indicated as oozing from the perforation. At and about the surface of the uterine wall which was adherent to the left ovary can be seen slight elevations (1) which proved to be superficial adenomyomas. Adenomyoma of the endometrial type as found developing between the adherent right ovary and ligament and the surface of the uterine wall at A. Sections were taken from other portions of the uterine wall and the ovaries at four B.

ficial red or purplish elevations on the pelvic structures. On the other hand their invasive tendencies may lead to deep involvement of the ovaries, causing the formation of cysts which are filled with old menstrual blood commonly called chocolate cysts.

The gradual increase of the contents of the cyst leads to perforation of the cyst wall with a second dissemination of endometrial tissue for further implantation in the cul de sac, rectovaginal septum, rectum and uterine wall. Adenomyosis, a benign invasion of

characteristics common to müllerian tissue wherever located.

**Pathology.**—The microscopic picture of endometrial lesions wherever found is fairly uniform. The glands are lined with a single layer of cuboidal or cylindrical epithelium with darkly stained centrally placed nuclei. Endometrial hematomas of the ovary vary in size from minute superficial lesions involving only the surface of the organ to large cysts measuring several centimeters in

diameter. The small cysts are recognized as small red or purplish bodies on the surface of the ovary, the color depending on their age and the period of the menstrual cycle. The implants may affect only one ovary, although both are usually involved. The larger growths have their origin deep within the substance of the ovary. As the adenomatous lesion responds to the ovarian stimulus, bleeding occurs and cyst formation results. Perforation eventually occurs, the irritating contents are widely disseminated in the pelvis, causing secondary transplants that have more invasive tendencies than the original transubal epithelium. Sampson believes that the ovary acts as a hotbed for the

associated pathologic findings are important from a diagnostic standpoint. The frequent incidence of endometriosis as a complication of fibroids of the uterus is striking, nearly one half of the cases will be found associated with fibroids. Retrodisplacements of the uterus and chronic pelvic inflammatory disease rank next in frequency.

Next to perforating hemorrhagic cysts of the ovary, the most characteristic lesion is endometriosis or adenomyoma of the recto-vaginal septum. The growth usually presents as a diffuse nodular thickening in the vaginal vault, which frequently involves and fixes the cervix as well. Cullen's classification is authoritative:

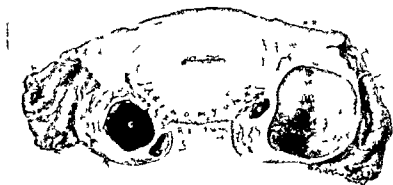


Fig. 691.—Cross section of the uterus and ovaries (natural size) indicating the condition found at operation. Both ovaries were adherent to the posterior surface of the uterus and the perforations. The adenoma has spread over the surface of the uterus and was just beginning to invade it. The relation of the rectum to the uterus is indicated by the dotted lines. The larger hemorrhoma (c) of the left ovary is shown in longitudinal section and also the smaller one (c) of the right ovary with the graafian follicle cyst lateral to it. Sections of the uterine wall failed to show any endometrial tissue between the superficial growth on its posterior surface and the mucosa of the uterine cavity.\*

primary implants and that the secondary growths possess more active properties through having become accustomed to their environment. Whenever perforation occurs the opening is promptly sealed or walled off by the adjacent structures and the adhesions that result become so dense and fused that the type is characteristic. Beneath these dense peritoneal adhesions, adenomatous invasion of the deeper structures of the intestinal wall, rectum, rectovaginal septum and uterus may be found. It then becomes an infiltrative rather than a destructive process. Only the ovary produces the larger destructive cysts and the adhesions about them are so dense, owing to the infiltration of the underlying tissues that removal without rupture is practically impossible. The

- 1 Small adenomyomas lying free in the rectovaginal septum.
- 2 Adenomyomas adherent to the posterior surface of the cervix and at the same time to the anterior surface of the rectum.
- 3 Adenomyomas gluing the cervix and rectum together and spreading out into one or both broad ligaments.
- 4 Adenomyomas involving the posterior surface of the cervix, the rectum and the broad ligaments and forming a dense pelvic mass that cannot be liberated.

Other typical lesions are those found in the inguinal canal, the round ligaments, the umbilicus and laparotomy scars.

\* Sampson, Arch. Surg. 3.

**Symptoms.**—Endometriosis may be a slow and insidious disease. Amazing destruction may take place with few if any symptoms to point to its presence. As a rule the symptoms are progressive and depend largely on the complications. Pain usually dull and aching in character localized low in the abdomen and back and always aggravated during the menstrual period is frequently emphasized. Acquired dysmenorrhea is very suggestive; menorrhagia and metrorrhagia appear in about one half of the cases and dyspareunia is more common than any of the other symptoms. There is nothing really characteristic in the symptoms by which a diagnosis can be made. Keene insists very correctly that it is not a single symptom but rather the symptom complex that aids in making a differential diagnosis and he emphasizes the following points: (1) age between twenty-five years and the menopause (2) sterility absolute or relative (3) abnormal menstruation usually menorrhagia (4) dysmenorrhea of the acquired type (5) dyspareunia (6) sacral backache (7) intermenstrual lower abdominal pain with increased discomfort at the time of menstruation and (8) pain in the rectum or bladder which bears a distinct relation to menstruation.

**Diagnosis.**—The majority of the cases of endometriosis are not recognized before operation. The usual diagnosis is chronic pelvic infection or fibromyoma of the uterus associated with diseases of the appendages. Vaginal examination reveals a tender densely adherent semi-solid or firm a fixal mass. The uterus is retrodisplaced and adherent. The only distinctive lesions are the nodular fixed masses which are palpated in the cul-de-sac. Rectal examination should always be made as it reveals more evidence than vaginal palpation. Proctoscopic examination is of distinct value in differentiating a malignant growth. The rectal mucosa overlying the nodular masses is normal in endometriosis but rarely so in carcinoma. Nodular areas in the vaginal vault often show the tell tale red or purplish spots and are conclusive evidence when found. The rectovaginal septal lesions may exist without ovarian invasion but in outlining treatment it must be remembered that both are more frequently involved. There are no

characteristic symptoms in widely situated lesions such as in the umbilicus laparotomy scars and the inguinal canal other than the exaggeration of symptoms and occasional bleeding during menstruation. Green Armytage has found injections of milk of value in differentiating between chronic pelvic infection endometriosis and pelvic tuberculosis. He insists that the reaction following these injections which commonly occurs in infections does not occur in endometriosis or tuberculosis. The condition has been confused with pelvic tuberculosis. Green Armytage emphasizes the value of the von Pirquet test when tuberculosis is suspected.

**Prophylaxis.**—Endometrial growths according to Sampson rank in frequency next to uterine myomas. If transabdominal implantation is the method of dissemination rough pelvic examinations during or near the onset of menstruation and tubal insufflation as well as operations too soon after menstruation may figure as exciting factors in the transportation of the endometrial cells.

**Treatment.**—The activity of all endometrial growths depends on ovarian function. When menstruation ceases retrogressive atrophy of the lesions follows. In this lies the keynote to successful treatment. The treatment is essentially surgical. In women forty years of age or more the problem presents no perplexities—removal of the ovaries releasing adhesions and often hysterectomy are indicated. In younger women conservative measures must be followed. Too often radical operation is necessary but small chocolate cysts may be removed by resection or the ovaries, one ovary may be saved. Small lesions on the intestinal wall or mesentery may be cauterized and complete function may be restored. The tubes are usually patent and 28 per cent of Keene's patients subsequently bore children. Unfortunately many patients may require a secondary operation and if extensive endometriosis is found at operation removal at least of both ovaries is indicated. This applies as well to extensive infiltration of the rectovaginal septum and more particularly to involvement of the rectum. In many of these cases the patient has been subjected to radical resection of the intestine under a mistaken diagnosis of cancer.

Radium and x-ray treatment are rarely

indicated. Conservation of the ovaries should always be attempted when possible and irradiation will not remove adhesions and chocolate cyst collections. Furthermore it is too difficult to differentiate between endometriosis and chronic pelvic infection to run the risk of lighting up a latent disease which is so likely to occur after irradiation.

C. JEFF MILLER

REVISED BY WILLIAM C. DANFORTH

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## BENIGN LESIONS OF THE CERVIX

### INFLAMMATION OF THE CERVIX\*

The cervix is prone to infection because pathogenic and non pathogenic bacteria are always present in the vagina. No habitat is more inviting to the gonococcus than the columnar epithelium of the endocervix and underlying racemose glands. The resulting infection causes swelling and edema which narrow the cervical canal and prevent proper drainage. Infection plus poor drainage always leads to more extensive and deeper inflammation. The cervix has been called the tonsil of the vagina because of the similarity in the behavior of the two structures. Chronic endocervicitis is one of the most common gynecological lesions.

**Etiology**—Endocervicitis may be caused by (1) gonorrheal infection (2) postabortal and postpartum infections with or without lacerations (childbirth instrumentation

etc) (3) cervical trauma from any cause plus infection and (4) hematogenous infection.

**Acute Endocervicitis**—Acute endocervicitis is not commonly observed because by the time the patient is first seen the acute stage of the inflammation has passed.

**Pathology**—The endocervix and to some extent all the cervical tissues are reddened and edematous. There is a mucopurulent or purulent discharge. Microscopically there is an acute inflammation with edema, round cell infiltration and engorgement. The columnar epithelium of the mucous membrane of the endocervix as well as the squamous epithelium about the external os shows degenerative changes.

In acute endocervicitis particularly if gonorrheal there is danger of upward extension into the uterine cavity and thence to the fallopian tubes, ovaries and peritoneum. If the cause is the streptococcus staphylococcus *B. coli* or some other pathogenic bacterium or a mixture of these extension is largely through the lymphatics to the parametrium then to the peritoneum, fallopian tubes and ovaries.

**Symptoms**—In acute endocervicitis systemic symptoms are absent or slight. There may be general malaise, lower pelvic discomfort and backache. Purulent or mucopurulent leukorrhea is always present. Often if the infection in the cervix is coincident with vaginal or pelvic infection or trauma or both the symptoms of these predominate.

**Diagnosis**—Inspection reveals the presence of a copious discharge. If gonorrheal is suspected examination of smears confirms the diagnosis. When the acute stage has subsided examination can be made more satisfactorily and with less trauma.

**Treatment**—Rest in bed with promotion of drainage and cleanliness are paramount. For cleansing purposes a warm alkaline douche is invaluable. It should consist of from 2 to 4 quarts of warm water with half an ounce of bicarbonate of soda or any alkaline agent several times a day alternating with 1:5000 potassium permanganate solution when the diagnosis of gonorrhea is certain. Topical applications are used but little today as they are somewhat traumatic and often do more harm than good. If the lesion is gonorrheal in origin sulfathiazole in full

\* Endocervicitis and cervicitis will not be differentiated in the discussion of clinical folklore.

the cases in group 1 and 2 and the upper half of group 3 may be successfully treated with the electric cautery. In cases in the lower half of group 3 and all of group 4 cautery treatment is contraindicated, the

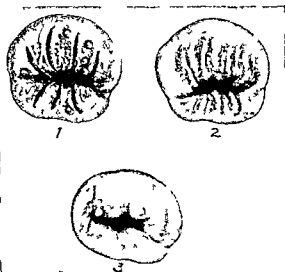


Fig 655.—Method of stripping and stages of healing. All visible cysts should be punctured. The cautery is heated to white heat (never flaming red). Note the condition in 3 after complete healing.\*

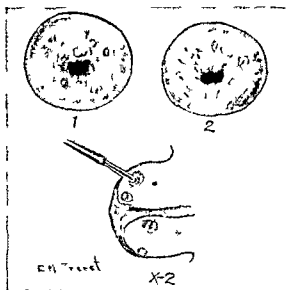


Fig. 656.—Technic of puncturing cysts in a nulliparous cervix. Note the small size of the cautery tip used.\*

Sturmdorf or "cone" operation (which is not an amputation in any sense of the word) or amputation using a modified Sturmdorf technic gives most satisfactory results

Medical treatment by topical application tampons etc. is useless except when the

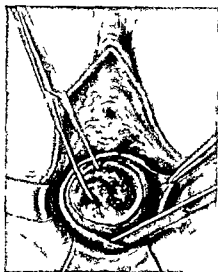


Fig 657.—Incision is made just external to the outer limits of erosion. The mucous membrane is separated along the line of cleavage. Sufficient flap must be separated to cover over completely the denuded cone area.

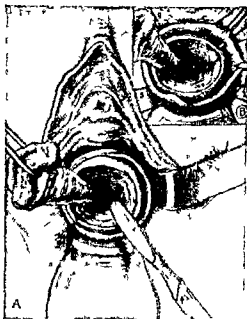


Fig 658.—1. Cone excision on of the infected area completed but the cervical canal has not been opened. The cone is used as a tractor to facilitate the placing of sutures as shown in B. Suture 1 begins at 3 30 and emerges at 3 30. Suture 2 begins at 1 30 and emerges at 4 30. Suture 3 should not enter but must approach the cervical canal.\*

infection is superficial and has had a short duration

\* Matthews JAMA 87

Briefly the technic of cauterization of the cervix is as follows. The cervix is exposed

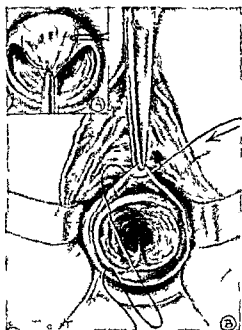


Fig. 699—1. Estimating the extent of the flap needed and the method of placing the first stitch of a double inverting stitch. 2. Technique of placing the first half of a double inverting stitch. The needle is well up in the cervical canal.\*

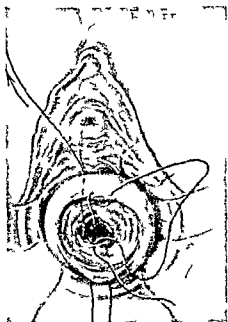


Fig. 700—Second half of the double inverting stitch. It is important to have sufficient mucous membrane to cover all the denuded area.\*

cleansed and dried (groups 1 and 2). With the small nasal cauterizer incisions (stripe)

are made extending from the internal to the external os and out over the eroded area to normal mucous membrane. Two three or more of these stripes from 0.5 to 1 cm apart and from 3 to 6 mm deep are made

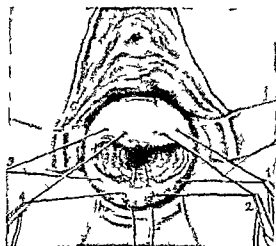


Fig. 701—The anterior and posterior labial clamps are applied to the lateral sutures are pulled taut. 3. The previous to tying 1, 2, 3, 4.\*

over each lip of the cervix (Fig. 699). Cysts are punctured if visible. Where it is necessary to extend the incisions deeper (groups 2 and 3) local anesthesia may be necessary and only one lip should be stripped the

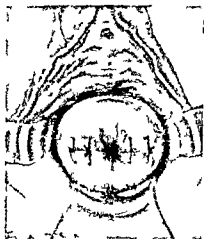


Fig. 702—All the sutures are tied and the operation is complete. Only silk sutures are used.\*

procedure being repeated on the opposite lip two weeks later. In order to promote healing and minimize further infection 4 per cent mercurchrome is copiously ap-

\* Matthews JAMA 87

plied to the cervix and vagina. A daily alkaline douche is ordered. Further cauterization may or may not be needed.

In the nulliparous non-eroded cystic cervix the wire cautery tip should be used for puncturing the cysts and stripping the mucous membrane (Fig. 696).

The technic of the Sturmdorf operation with certain modifications is as follows. With the patient in the lithotomy position the anterior and posterior lips of the cervix within the margin of the erosion are grasped and the cervix is pulled down. An incision is made through the mucous membrane of the portio encircling the outer limits of the eroded area. The mucosa of the portio is dissected back for a distance of 2 or 3 cm. or more to obtain sufficient mucous membrane to cover the excised area completely (Fig. 697). With a scalpel the entire gland-bearing area of the cervical canal is coned out, the excision extending to or just below the internal os (Fig. 698 A). Great care should be exercised so as to preserve the muscle tissue and remove the infected area. If too much cervical (muscle) tissue is removed the operation becomes an amputation (high or low) but this should be avoided. If not enough tissue is removed and the infected glands are left the operation will be a failure. Lateral sutures two on either side are next placed at strategic points (Fig. 698 B) and held as traction sutures. The final step of the operation is to cover over with the loose vaginocervical cuff the funnel-shaped cavity left by the removal of the cervical cone. There should be ample cuff to insure good apposition without tension which is chiefly accomplished by a double inverting stitch (Figs. 699 A and B and 700) passing through both anterior and posterior lips of the newly formed cervix. With all six sutures tied thorough coaptation of the vaginocervical cuff is obtained and complete hemostasis is accomplished (Figs. 701 and 702). A small strip of mercurochrome gauze drain is placed against the cervix. This should be removed in twenty-four hours.

Other methods recommended in the treatment of chronic endocervicitis are the following:

**Diathermy.**—Cherry, Corbus and O'Connor, Ward and others are enthusiastic over

their results obtained with diathermy. A therapeutic temperature of from 109° to 113° F. may be attained in the cervix and this is lethal for gonococci. Generally heat in chronic pelvic infections relieves pain, diminishes pelvic masses and aids in complete resolution.

**Coneization.**—This was introduced by Hyams of New York. The diseased endocervix is excised by means of a fine, smooth high frequency current. End results are excellent but the apparatus which is employed is expensive.

**Radium.**—Irradiation has been recommended but is not advised for the following reasons: (1) It may produce acute exacerbation of a chronic inflammation. (2) It may have a deleterious action on the ovaries, sometimes even after a small dosage. and (3) it tends to produce stricture of the cervix.

### SYPHILIS OF THE CERVIX

Reliable reports of syphilis of the cervix are rare. Gelhorn and Ehrenfest in 1916 published their excellent work on syphilis of the generative tract and their description of syphilis of the cervix is standard. According to these authors cervical chancre is rare. The lesion contains many spirochetes and the diagnosis is made by a dark field study of smears. The Wassermann reaction at this stage is negative.

Secondary syphilis of the cervix occurs as condyloma latum and is readily recognized. The Wassermann reaction is positive. Secretions contain many spirochetes.

Tertiary syphilis of the cervix is said to be most common. The lesion is a yellowish ulcer with indurated edges which secretes a profuse yellowish discharge (gumma). Spirochetes are present in the secretions and curettings from the base of the gumma. The reaction to the Wassermann test is positive.

**Symptoms.**—There is nothing pathognomonic but syphilis may be suspected on examination. A history of contact is helpful. Secretions and curettings from the ulcerated areas reveal the *Spirochaeta pallida*.

**Treatment.**—General antisyphilitic treatment is indicated and is curative. Cauterization, electrocoagulation and surgical treatment are contraindicated.

## TUBERCULOSIS

Tuberculosis of the cervix is very rare. Generally it is secondary to tuberculosis of the endometrium and/or endosalpinx. It appears as an ulcerated area about the external os or in the cervical canal as an easily bleeding papillary mass near the os or as miliary tubercles scattered over the cervix. A positive diagnosis can be made only by biopsy.

**Symptoms**—There are no characteristic symptoms. Leukorrhea is usually present. If tuberculosis exists elsewhere its symptoms are present.

**Treatment**—High amputation of the cervix should be performed if the lesion is not extensive. Electrocoagulation has been recommended. If the extent of the tuberculous process is doubtful panhysterectomy is indicated. The general treatment of tuberculosis is essential.

Actinomyces echinococcus and hilharzia infections of the cervix are extremely rare. Actinomyces is probably more common than is generally supposed (Graves) because it is easily confused with gonorrheal or tuberculous infection.

## CONDYLOMA ACUMINATUM

A condyloma acuminatum (moist wart) of the cervix is usually associated with gonorrheal infection but may occur with any persistent irritating discharge. The condylomas occur singly or in groups on the vaginal portion of the cervix and are to be distinguished from the condyloma latum of secondary syphilis.

**Treatment**—Cleanliness is important and an alkaline douche once or twice a day is useful. The warts may be destroyed by fulguration, the electro-surgical knife or the actual cautery. A chemical escharotic, e.g. formalin or trichloroacetic acid may be used. The application of vaselin serves to prevent injury to the surrounding tissues. Local anesthesia is usually indicated before mass removal. The use of 4 per cent solution of mercurochrome or sulfanilamide powder promotes healing and minimizes the likelihood of further infection.

## STENOSIS OR STRICTURE AND ATRESIA OF THE CERVIX

Stricture or atresia of the cervical canal may be congenital or acquired (usually ac-

quired) and may be located in any part of the cervical canal from the internal to the external os. Atresia is frequently found at the external os.

**Etiology**—Deep seated virulent infections of the endocervix, trauma incident to inappropriate topical treatment, extensive cauterization, poorly executed operations and trauma of childbirth may cause stricture (stenosis) or atresia or both. Atresia frequently follows scalpel or electro-surgical amputation of the cervix and irradiation for chronic infection or carcinoma of the cervix. Elderly women after the menopause are likely to have atresia.

**Symptoms**—The symptoms vary depending on whether the cervix is partially or completely closed. Leukorrhea is the outstanding symptom of stricture. Atresia causes hematometra, the symptoms being similar to those in amenorrhea—severe menstrual pain or constant abdominal pelvic pain, lower abdominal tumor and general debility. Hematosalpinx with leakage of blood into the peritoneal cavity may be the end result of hematometra and may cause peritoneal irritation with pain, rigidity, tenderness over the distended uterus, fever, rapid pulse, etc. In the aged pyometra is occasionally encountered.

**Prognosis**—The prognosis is good if drainage through the cervix can be secured and poor if the symptoms are severe and it is necessary to resort to anterior hysterotomy or hysterectomy.

**Treatment**—Treatment consists of dilation of the cervix with or without anesthesia. A small uterine sound or small uterine dressing forceps is introduced past the stricture or stenosis or atretic area. When this cannot be accomplished, thorough dilation of the cervix should be attempted under anesthesia. If this cannot be accomplished, anterior hysterotomy or hysterectomy should be performed.

## CERVICAL POLYPS

Cervical polyps are of two types: (1) glandular and (2) fibrous. The glandular type of polyp is the result of an inflammatory outgrowth of the cervical mucous membrane and is the more common. The fibrous type arising from the musculofibrous portion of the cervix appears as a small pedunculated fibromyoma hanging through the external os.



**Etiology**—The mucous type of polyp is the result of a chronic inflammatory outgrowth of the cervical mucous membrane or of the corporeal endometrium. The fibrous polyps apparently occur in the same patients as do fibroid tumors and consequently little is known of their cause.

**Pathology**—The glandular polyp may be single or multiple and appears as a small bright red growth at the external os. It is covered with columnar epithelium or partly with columnar and partly with squamous epithelium and consists of a vascular connective tissue stroma containing many racemose glands. Usually there is chronic inflammation. The fibrous polyp is also covered with columnar and/or stratified epithelium containing fibrous or muscle tissue richly supplied with blood vessels.

**Symptoms**—Polyps often slough in the dependent portion and intermenstrual bleeding (metrorrhagia) is common. Spotting following coitus is also frequent. Leukorrhea streaked with blood may be present. Larger polyps, particularly the fibroid type, often cause menorrhagia.

**Diagnosis**—The diagnosis is simple and is made on inspection.

**Treatment**—Smaller polyps may be removed in the office with the actual cautery or electro-surgical knife with no fear of subsequent bleeding. Simple ligation of the pedicle and excision of the proximal portion of the polyp will suffice, but subsequent recurrence is more frequent. Larger or sloughing polyps should always be examined for malignant changes.

When anesthesia is used for other operations, dilation and curettage of the uterus and cervix will remove all polypoid growths. When the polyps are large they may be removed by anterior hysterotomy. In elderly women trichomy may be used to destroy the cervical mucous membrane and prevent recurrence. In such cases the cervix should be repeatedly dilated in order to prevent stricture.

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#### SURGICAL LESIONS OF THE VAGINA

Among the more common surgical lesions of the vagina are those resulting from traumatic injury. Before marriage there occasionally occurs the injury coincident with forceful coitus—not always rape—and the injury that results from external violence such as falling astride a chair or sharp pointed object for instance a picket fence or ornamental post traumatizing the vagina in varying degrees. Occasionally the urethra, bladder or rectum also is injured. After marriage injuries due to childbirth—rectocele, cystocele and prolapse—are common lesions.

Acquired atresia or stenosis (complete or partial closure) of the vagina occasionally occurs as the result of extensive traumatic injury followed by infection and scar formation. Extensive ulcerations from any cause notably escharotic chemicals used in douches or suppositories malignant and syphilitic ulcerations extensive inflammatory processes and more commonly adhesive senile vaginitis of the aged may cause atresia of the vagina.

**Treatment**—The management of a traumatic injury of the vagina other than that due to childbirth depends on the character and extent of the wounds. A small wound needs only to be sutured after all bleeding

has been controlled. A large laceration may require an extensive plastic operation. When there is also injury to the urethra, bladder or rectum the problem becomes more complicated and calls for delay in operation in order that asepsis may be obtained. The most important requisites for a successful plastic operation are hemostasis and asepsis. Since the advent of the sulfa drugs infections are less troublesome. From 5 to 8 mg of the appropriate sulfonamide may be sprinkled into the wound as a prophylactic. If in spite of all prophylactic measures infection sets in chemotherapy with the appropriate sulfa drug is indicated in full therapeutic dosage. Every plastic surgical operation should be successful in the absence of infection while in its presence complete or partial failure is almost certain to follow. (See section on General Principles of Plastic Surgery.)

In general in repairing a wound in the vagina the surgeon should make every effort to leave the least amount of scarring possible and to reestablish the normal vaginal orifice as accurately as possible. Scar tissue makes for painful coitus and disappearance causes unhappiness in many families.

In the treatment of atresia of the vagina the method of approach will be determined by the cause. Dissection of the dense scar tissue with plastic restoration of the vaginal canal is usually all that can be done. When the atresia is the result of severe senile vaginitis in an elderly woman separation of the adherent surfaces by blunt dissection followed by a light iodoform pack usually suffices. The walls of the vagina must be kept separated for twelve to fourteen days or longer in order to prevent reformation of adhesions. This can be accomplished by placing sterile rubber tissue or the cuff of a rubber glove properly shaped in the vagina after the removal of the original iodoform pack. The rubber tissue form should be replaced every few days at which time the vaginal canal may be sprayed with a suitable germicide (4 per cent mercurochrome). Immediately after operation an estrogenic hormone should be given intramuscularly in large doses (10,000 units) daily or twice weekly to stimulate epithelial growth over the impoverished vaginal mucous membrane. Results are uniformly good.

Lacerations resulting from childbirth and manifested in the form of rectocele, cystocele and prolapse are discussed elsewhere (See section on Displacements of the Uterus).

**Cysts**—Cysts of the vagina are relatively rare. They may be either congenital or acquired.

A congenital cyst of the vagina may arise from an embryonal rest from the remains of Gartner's duct (vaginal portion of the Wolffian duct) and/or the Mullerian duct.

An acquired cyst of the vagina may arise (1) from an aberrant vaginal gland (2) from an inclusion of epithelium after an operation on the vagina, traumatic injury or laceration due to parturition (3) or after an abscess of Bartholin's gland or (4) rarely it may be due to a dermoid or echinococcus cyst. A vaginal cyst may be small (the size of a pea) or very large filling the vagina. Occasionally such a cyst becomes pedunculated and delivers itself out of the vagina. It is usually spherical or oblong but owing to pressure or other external forces it may become elongated or cylindrical or may assume some other unusual shape.

**Symptoms**—A vaginal cyst usually produces no symptoms unless it attains sufficient size to interfere with coitus or unless it becomes infected. Infection is extremely rare but when it is present the usual symptoms of acute inflammation appear. If the cyst grows to considerable size symptoms caused by pressure on the bladder, urethra or rectum may appear. If pregnancy occurs such a cyst may prevent or retard the descent of the presenting part during labor and delivery.

**Treatment**—Excision is the only effective treatment for a cyst of the vagina. Mere incision and aspiration of fluid is not curative. In rare instances and under unfavorable circumstances (infection or emergency) incision and cauterization of the sac followed by packing with iodoform gauze may accomplish the desired result. When the cyst or cysts are situated high up in the vaginal vault and perhaps extend up between the layers of the broad ligament (embryonal cysts) extirpation may become extremely difficult and may be attended with considerable danger to the patient (e.g. injury to important pelvic structures such as large

blood vessels bladder ureter rectum or pelvic peritoneum)

The prognosis is good in all cases in which the cyst wall is completely removed. In cision only with or without cauterization of the sac and with packing of the cavity with iodoform gauze is likely to be followed by recurrence of the cyst.

### NEW GROWTHS

**Benign Growths**—A fibroma, fibromyoma, adenomyoma or endometrioma occasionally develops in the vaginal wall. If it is of sufficient size to produce symptoms, extirpation is the proper treatment. Before attempting extirpation, however, one should be sure of the diagnosis, since a fibroid or vaginal hernia might be mistaken for a soft myoma or endometrioma. (See section on Endometriosis.)

A venereal wart (condyloma) in the vagina usually occurs as an extension of such a growth from the vulva and is associated with gonorrheal infection. It may occur also on the vaginal portion of the cervix. It is to be distinguished from condyloma latum of secondary syphilis. Excision in the office or hospital with the actual cautery or radio knife or by fulguration is the method of choice in removing these growths. Excision with the scalpel may be done when the aforementioned modalities are not available. Hemorrhage must be controlled. Local anesthesia is usually all that is required. The generous use of 4 per cent mercurochrome or some other antiseptic minimizes the chances of infection.

**Malignant Growths**—Primary carcinoma (squamous cell type) of the vagina is extremely rare. Secondary or metastatic carcinoma of the vagina may occur from any malignant growth in an adjacent pelvic structure, the cervix being the most common site of the primary carcinomatous lesion. Vaginal extension from a vulvar or rectal carcinoma is commonly encountered. The inguinal and pelvic glands are invaded early. The prognosis is accordingly bad unless diagnosis is made early and proper treatment is carried out.

**Symptoms**—Symptoms of the metastatic growth are those of the primary lesion (see section on Malignant Tumors of the Uterus) plus a watery, fetid discharge which may or

may not be bloody. Pruritus is usually present. Bleeding may later become excessive. Pain is likely to be a late symptom.

**Diagnosis**—The diagnosis is based on the physical characteristics of the growth (friability, bleeding on the least manipulation and infiltration) and microscopic examination of a biopsy specimen.

**Treatment**—The treatment of the primary lesion is fully discussed elsewhere. (See sections on Malignant Tumors of the Uterus, Carcinoma of the Vulva, Carcinoma of the Rectum and Anus.) Treatment of the primary vaginal growth is that of the malignant growth elsewhere in the pelvis. If it is localized early, complete radical extirpation is indicated; if extensive and if metastasis has occurred, irradiation is better (radium and/or deep x ray). In operative cases, irradiation after excision is always in order. Some authorities advocate irradiation both before and after operation. With either method, irradiation must be adequate over a period of from three to five years and at definite intervals. Here as elsewhere in the treatment of cancer, eternal vigilance is the price of success.

**Sarcoma**—Primary sarcoma of the vagina is extremely rare. In adults the growth may be anywhere in the vaginal canal. In children the vaginal cylinder is found to be filled with a polypoid grapelike mass which may have a basic attachment to any portion of the canal but according to good authority the attachment is more frequently to the anterior wall. Supposedly these primary growths in children and young adults originate in embryonal rests. These growths are highly malignant and of rapid growth and are frequently well advanced before advice is sought. There is rapid extension to the bladder, parametrium and pelvis generally. Metastasis to distant organs renders the prognosis uniformly bad.

**Symptoms**—Vaginal discharge which may be serosanguineous, mucopurulent, bloody or blood streaked and which has a fetid or foul odor and later frank hemorrhage are suggestive. Pain may or may not be present. Microscopic examination of a biopsy specimen establishes the diagnosis.

**Treatment**—The treatment is the same as that for carcinoma of the vagina. Secondary or metastatic sarcoma from structures

near or in juxtaposition to the vagina may occur. The symptoms and treatment are the same as those of the primary growth.

**Chorioma, or Chorionepithelioma**—Chorioma or chorionepithelioma of the vagina may occur although rarely as a metastatic growth or as a transplant from chorioma of the uterus (See section on Chorionepithelioma).

### INFLAMMATION (SURGICAL)

**Tuberculosis**—Tuberculosis of the vagina rarely occurs as a primary lesion but is more frequently secondary to tuberculosis higher up in the reproductive or genitourinary system (e. g. uterus oviducts bladder ureters or kidneys). Because of this the posterior wall of the vagina is the most common location of the lesion.

**Symptoms**—The lesion usually appears as an ulcer in which tubercles may be identified. Later confluent ulcers make their appearance and thus extend to surrounding structures such as the bladder and rectum. There is little or no pain. The discharge is seropurulent and later perhaps blood stained. This lesion must be differentiated from a malignant or syphilitic ulcer.

**Treatment**—Destruction of the ulcer or ulcers with the actual cautery is recommended when the lesion is single and small. When it is extensive, excision is the procedure of choice. Irradiation (x-ray or radium) has been used with good success. If tuberculosis of the endometrium or fallopian tube exists panhysterectomy when feasible should be performed (See section on Tuberculosis of the Cervix).

### FOREIGN BODIES IN THE VAGINA

**Foreign bodies in the vagina** e. g. a forgotten pessary, part of a broken douche tip, a large safety pin or any cylindrical object used in masturbating which remains *in situ* for a long period produces discomfort, pain and leukorrhea which is seropurulent, bloody, fetid or foul. Such symptoms may be mistaken for those of malignant disease and it is only after thorough investigation that the correct diagnosis can be made.

**Treatment**—Treatment consists in removal of the foreign body. Often this is easy with or without anesthesia. However it occasionally happens that the object inserted

is deeply embedded in the vaginal tissues and considerable damage may be done in its removal. e. g. in one of the author's cases a ring pessary had remained embedded in the anterior wall of the vagina for nine years and when it was dissected free a large vesicovaginal fistula resulted. Many queer and formidable objects have been removed from the vagina in cases of insanity.

### VAGINISMUS

**Vaginismus** is a spasmodic painful involuntary contraction of the muscles of the introitus (sphincter vaginae) and the lowermost segment of the vagina (anterior portion of the levatores ani). It appears most frequently in newly weds although it may occur in women who have borne children and not infrequently during or past the menopause.

**Etiology**—The cases of this condition fall into two groups: (1) those in which no cause is demonstrable and (2) those in which a definite cause is ascertainable. The underlying cause in all cases is undoubtedly neurotic in origin. However not infrequently there is coupled with this basic condition a urethral caruncle, an inflamed rigid hymen, an unhealed lacerated hymen or a vaginal or rectal fissure which aggravates the hyperesthesia of the vaginal orifice producing frank vaginismus. During or after the menopause atrophy of the external genitals and contraction of the introitus together with dryness of the parts a constant annoyance with the cessation of ovarian function often lead to a severe and intractable type of vaginismus.

**Symptoms**—Symptoms do not appear until coitus is attempted. Intercourse is found impossible. The hyperesthesia of the parts is so extreme that the lightest touch causes intense spasm and pain. The patient cries out, the thighs become strongly abducted and further approach is impossible. Examination by the physician is always trying and exasperating. Indeed it is frequently impossible until complete anesthesia is induced. In the older and more experienced group the appearance of some pathologic lesion of the vulva, vagina or rectum plus a neurotic tendency associated with hyperesthesia of the parts causes pain and spasm on intercourse. During or after the menopause

pause atrophy contraction and dryness of the parts are responsible for fear and pain on intercourse

**Treatment**—The first step in treatment consists in allaying or removing the cause and the second is gradual and complete dilation of the vaginal orifice and lower segment of the canal. If there is no demonstrable lesion the administration of sedatives or hypnotics for the alleviation of the extreme nervousness and disunion of the vaginal orifice under anesthesia will suffice. Occasionally in the mild case speculum stretching of the introitus and canal in the office or at home and immediate intercourse plenty of lubrication being used may effect relief. In severe cases even after removal of all visible causes coitus remains impossible or unsatisfactory. In such cases operation is imperative and is designed to enlarge the vaginal introitus. The Hirst operation is commonly employed. It consists in making a longitudinal incision in either side of the orifice (inside the skin line) and extending it for 2-3 or more centimeters up each vaginal sulcus incising the mucous membrane and superficial layer of underlying muscle (1 or 2 cm deep). These incisions are sutured transversely thus widening the vaginal entrance. Later when complete healing has taken place coitus can be accomplished without spasm or pain.

General hygienic measures sedatives and reassurance from the physician do much to relieve an otherwise disastrous situation particularly in the newly married. For women at or past the menopause sedatives and plenty of lubrication are the only means of treatment.

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#### DISEASES OF THE VULVA

Vulvar symptoms and even vulvar lesions at times are of only secondary import to extension or spread from another site such as the vagina or cervix or even dermatological

lesions external to the labia. Some of the conditions which may require surgical treatment or a differential diagnosis from a therapeutic viewpoint will be considered in the following paragraphs.

#### HYPERTROPHIC STATES

1 **Elephantiasis or Filariasis**—The primary agent of filariasis is *Wuchereria bancrofti* (*Filaria bancrofti*). Streptococci or staphylococci may play a considerable role later according to Strong. Either the parasitic nematode or the bacteria alone or together cause a fluid and tissue reaction. In the broad sense different types of pathologic conditions may result from other species of the subfamily. Discussion here is restricted to the one type. Any obstruction to the lymphatic or circulatory system may cause enormous enlargement similar to that in filariasis. The labia may become greatly enlarged but is not comparable to the huge mass which occurs in scrotal growth. The tissue tends to be filled with lymphatic fluid and the dermis may take on a coarse pigskin effect. Labial edema as in heart failure or other passive congestion from pelvic abdominal or other local lesions or tumors may simulate early elephantiasis. These points and others must be considered in the differential diagnosis. Removal of the labial masses and at times portions of the mons veneris should be avoided during an active infectious state. Surgical removal is for rehabilitation in the broad sense. Until lately filariasis has been rare among the female population of the United States but there is increased likelihood of this condition among women who have served in areas where filariasis has been noted. Brown has reported on this in South Carolina and has noted the inguinal involvement in women.

2 **Hernia**—*Hernia of the vulva* is quite rare. However *inguinal hernia* has been known to descend along the inguinal or round ligament and canal of Nuck into the labia majora. *Hernia through the pelvic floor* is extremely rare. It may appear along the side of the vagina or may dissect down to the vulva directly. Intestinal obstruction may occur with either type of hernia. If bowel is in the area there should be definite tympany on percussion and other findings typical of hernia. It is improbable that omen

tum would descend as far as this Surgical correction is indicated for either or both of these types of hernia The repair must be directed toward replacement of the viscera and eradication of the ring through which the herniation occurred

**3 Condyloma Acuminatum**—At one time this condition was considered pathognomonic of prior gonococcal infection However it is now recognized as a condition occurring under various circumstances and is not a stigma of venereal disease unlike condyloma latum Condyloma acuminatum tends to be a gradually growing lesion and although it is epithelial in origin it tends to be moist It is commonly associated with a foul odor and an altered bacterial flora The individual growth may be shaped like a pine tree It varies in diameter from a millimeter or slightly less to a conglomerate mass measuring many centimeters in diameter Numerous forms of therapy have had their proponents Freezing agents antiseptics drying or desiccating preparations ligation surgical excision cauterization or fulguration each has its favorable points Surgical excision of any appreciable amount of tissue may be associated with extensive bleeding and yet it does not prevent a recurrence Recurrences are likely to follow any type of treatment Wolters and Hesseltine have illustrated the value of the use of radium Dosages varying from 75 to 450 mg hr were employed in their series This small dosage of radium applied externally should not endanger the ovaries or the reproductive tract yet it was followed with various satisfactory results It is suggested that about 100 mg hr is an optimum dose for an area of 4 sq cm If the first application of radium is not followed in a few weeks by complete disappearance additional radium may be re-applied This method eliminates incrimination it is safe and it is simple Extensive condylomas about the vulva may be a serious complication at the time of delivery because of increased danger of hemorrhage and also because they favor the growth of abnormal bacteria which may predispose to puerperal infection Consequently treatment during pregnancy may be well indicated and at the same time radium would not entail extensive blood loss X ray can be used but it is less easily restricted

**4 Syphilis**—Syphilis may manifest itself about the vulva as a *chancre condyloma latum or gumma* The diagnosis is confirmed by positive darkfield findings in the chancre or biopsy of the condyloma or gumma in which the classical histologic pattern will be found Serologic tests should be confirmatory for the latter conditions unless there has been adequate antiluetic therapy Surgical therapy is indicated only when adequate and proper antiluetic therapy has not been followed by reduction of the mass or sufficient improvement and if there are symptoms of sufficient magnitude Surgical removal may necessitate subsequent plastic reconstruction if there has been considerable deformity or destruction

**5 Chancreoid**—Chancreoid may produce enlarged inguinal glands which may suppurate and may be followed by chronically draining sinuses Kornblith Jacoby and Chargin used sulfathiazole and sulfanilamide The inguinal and vulvar glands associated with this infection should be protected from trauma and every precaution taken to prevent drainage Sulfonamides may be given during the active stage in an attempt to avoid suppuration Aspiration of the mass by passing a needle through normal healthy tissue and entering the area in directly or posteriorly may also have value Both surgical incision and spontaneous drainage are contraindicated for persistent sinuses follow frequently Once sinuses form they tend to persist and produce considerable cicatricial tissue Excision of these sinuses is frequently difficult

**6 Granuloma Inguinale**—Granuloma inguinale has somewhat the appearance of granulation type of tissue Torpin Greenblatt and Pund have reported on this condition It is encountered mostly in patients of poor hygienic type Surgical treatment is used only in the event that reconstruction or plastic procedures become necessary after the condition has been cured with furacin or antimony potassium tartrate (tartar emetic)

**7 Lymphogranuloma Venereum**—Lymphogranuloma venereum varies greatly in its manifestations It may produce only local enlarged lymphatic nodules or may in its greatest reaction cause complete obstruction of the pelvic sigmoid and even extensive ul-

ceration of the pelvis involving the rectum, vagina and urinary tract. This latter situation may terminate in a necrotic cloacal like crater. Perhaps the conditions heretofore called *esthiomene* and also probably occasionally *rodent ulcer* may be due to this destructive state. Medical treatment is indicated. Surgical correction is not directed at the local site but may be necessary to relieve intestinal obstruction or after the destruction has run its course to restore functional control. At a much later date after partial involution the colostomy wound may be closed.

**8 Tuberculosis**—Tuberculosis is less common today probably because of the better care and better hygienic measures available for persons with active infections. A local lesion on the vulva may be the result of blood stream dissemination or may be due to extension from the pelvic process. These lesions are usually irregular and may be quite destructive in these instances being painful. The slower growing lesions may be more hypertrophic. Occasionally a woman whose husband has pulmonary or urinary tract tuberculosis will have a tuberculous lesion on the vulva. Areas of suppuration may require drainage. Caution may be needed lest the abscess become dissecting.

**9 Pyogenic Infections**—Occasionally considerable edema, induration and general enlargement of a portion or all of the vulva result from pyogenic infection. These bacterial organisms may be the result of a primary urinary tract infection or may come from a primary lesion of the vulva. Should actual suppuration occur, drainage is indicated. In the event that actual suppuration has not occurred, sulfonamides may be very helpful either in ointment form or orally. The urinary tract and other focal sites of infection must be cleared.

*Bartholin's abscess* is moderately common and may be caused by the gonococcus, staphylococcus or any other organism which may be associated with suppuration. Bartholin's abscess like any other abscess should be drained when there is definite suppuration. The area is swollen, enlarged and red, dened, giving the typical picture of an acute inflammatory process. This condition must be differentiated from Bartholin's cyst or other non-inflammatory lesions which irri-

tate the skin. The incision should be made on the mucous membrane and should be adequate. Occasionally not all of the secretory cells will be completely destroyed by the infection and if a sinus forms between the glands and the surface, mucoid secretion from the gland should empty upon a mucous membrane which is normally moist. Drainage out on to a skin reasonably dry will become a source of irritation. The abscess will not transmit light, is not tympanitic and does not show evidence of enlargement on straining.

**10 Mycoses**—*Actinomyces* and *blastomycosis* are rare conditions of the female pelvic organs. Adequate surgical drainage may be necessary but surgical removal is frequently impossible. Occasionally, x-ray therapy and adequate sulfonamide therapy may be of some therapeutic value.

*Moniliasis* is a most frequent condition in pregnancy and occasionally in uncontrolled diabetes. The infection is superficial. It occurs because of an increased amount of available carbohydrate material when these fungi are present. The organism may be carried without symptoms or tissue reaction until a proper nutritive state occurs. The production of a glycogen like vaginal epithelium in the postmenopausal period by means of estrogens may result in frank vaginal moniliasis. The vulva may be infected secondarily and may be hyperemic and moderately swollen. If the patient yields to the impulse to scratch and usually the pruritus is most severe, there may be many areas of desquamation. The lesions may have a great similarity to those of atrophic vulvitis or kraurosis. The therapy is entirely medical for the diabetic patient and local fungicidal therapy is indicated for the diabetic as well as the pregnant patient. X-ray or surgical therapy is positively contraindicated.

**11 Hypertrophic Anomalies of the Vulva**—Hypertrophic anomalies of the clitoris are not so uncommon and misinterpretation of an enlarged clitoris may lead to great confusion about the sex of the child and its development. It may be necessary to amputate or remove a prominent clitoris in an older child or adult either to establish a normal psychologic behavior or to remove barriers for normal married life. Enlarged or pendulous labia likewise may be disturbing

and annoying. Under special circumstances it may be necessary to remove these pendulous portions of tissue. The labium is a vascular structure and its removal may be associated with severe blood loss.

### ATROPHIC STATES

**1 Atrophic Vulvitis (Leukoplakic Vulvitis, Kraurosis)**—Pruritis is the one common persistent and unrelenting symptom. Adair Davis and Schusterman made a careful study and have pointed out the three stages in the development of this condition. The first stage is one of inflammatory enlargement, edema, infection and pruritus. Abrasions and petechiae are not uncommon. The second stage is followed by involution or atrophy and beginning induration and thickening of the epidermis. There begins to be more of a mottled gray color. The third stage arrives when the skin has become inelastic, smooth, thin and parchment like. Leukoplakic areas may develop at this time or earlier and the vulvar area as a whole may not be uniformly in the same state. Since kraurosis is a condition which is followed in many instances by carcinoma, the commonly accepted treatment is vulvectomy, all of the altered pathologic tissue being removed. This may mean removing the mucosal area down to the hymenal ring and far laterally. When the skin lesions encircle the anus it is desirable to leave a strip on either side in which to anchor the rectum and at a later date when the first incisions have healed to remove the remaining tissue. The condition may recur. X-ray therapy has received some endorsement but since it does not prevent the development of cancer subsequently it is not recommended. Moreover it does not always cure the primary condition. Injections of alcohol and other medications under the diseased tissue or to the nerve supplying these areas seem only to eliminate the symptoms and not attack the disease. Various ointments and other medications have been recommended but do not always produce a cure. Hesseltine used large doses of members of the B complex and found improvement in a fair percentage of cases. It is possible that part of the conditions which heretofore have been recognized as kraurosis may actually be manifestations of vitamin deficiency. Until a sufficient num-

ber of tests and studies have been made upon patients with these lesions this question must remain controversial. Anyone attempting to use large doses of the B complex, ascorbic acid and perhaps other vitamins should be prepared to follow the patient sufficiently long to make sure that an absolute cure ensues or to institute appropriate surgical therapy lest a malignant growth develop. Skin changes in vitamin deficiency, particularly in pellagra, riboflavinosis and thiamine deficiency may be associated with changes similar to those in kraurosis. Taussig urges vulvectomy but warns against tightness and stenosis of the introitus (Fig 703).

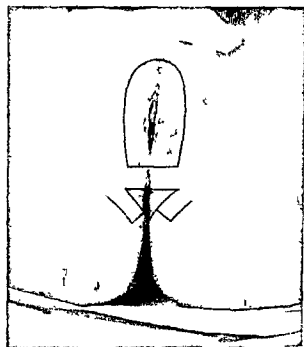


Fig 703—Operation for leukoplakic vulvitis. Vulval flap and double anal ellipse technique showing extent of denudation in an advanced case (Taussig).

**2 Phimosis**—Phimosis is rarely of importance in the female. Occasionally there may be redundant prepuce and constriction over the clitoris so that normal cleanliness and hygienic measures cannot be maintained. Occasionally and particularly in obese persons a low grade inflammatory process may become established under the preputial fold. Incision or circumcision is usually sufficient. Occasionally when the infection is quite chronic and persistent it may be necessary to amputate the clitoris near the bifurcation of the corpus spongiosum.



### 3 Atrophic Anomalies of the Vulva —

Atrophic anomalies of the vulva are likely to be the result of arrested development and accordingly will present little opportunity for correction or stimulation through hormonal or other therapy in adults. There is little chance of improvement by surgical means except by plastic reconstruction. This applies particularly if there is a small introitus in which case perineotomy or introital dilation alone may suffice. To correct dyspareunia due to a small introitus the lubricated vagina should be dilated and a midline incision made of sufficient degree. Occasionally a single or even a double mesolateral incision may be justified. After adequate room is obtained the vaginal mucosa is brought down to the skin so that the sigaital incision is closed transversely.

### BENIGN NEOPLASMS

1 Bartholin's Cyst — Bartholin's cyst results because of occlusion of the duct from Bartholin's gland. Infection or injury is the likely cause for occlusion. Small or asymptomatic cysts are not sufficiently important as a rule to require surgical attention. Any cyst which produces symptoms or which is large enough to interfere with locomotion coitus or delivery should be removed. A Bartholin's cyst transmits light. Even though it may dissect upward into the labium majus it is concrete and sharply defined. It is dull on percussion and does not have an impulse with sudden straining. It can be aspirated and filled with a solidifying oil or fat such as paraffin which would melt at about 40 to 42° C. Most surgeons prefer merely to incise the skin and enucleate the cyst without making a mold of the cavity. The incision may be made either on the normal epidermal area or in the mucous membrane. It is recommended in most instances that the incision be made on the mucous membrane over the length of the cyst proper and that blunt dissection be used to free the cyst from the adjacent tissue. Bleeding points and vessels will be found near the depths of the cavity, and after the cyst has been freed to this site, hemostats should be placed along the pedicle like area. This will allow for detachment of the cyst and will also prevent the vessels from retracting. After bleeding points are properly controlled the cavity is closed with

interrupted buried catgut suture, probably chromic No. 1 will be preferable. The skin area can be closed either with fine catgut or with a non absorbable suture such as cotton or silk. It is important in the event that the cyst is opened that the complete cyst wall be removed otherwise there is great likelihood of recurrence.

2 Hydradenoma — Hydradenoma is a tumor arising from the sweat glands. Usually it is of moderate to small size but may be disturbing to patients. When sufficient symptoms are present removal is indicated.

3 Fibroma and Lipoma — Fibroma and lipoma of the vulva are tumors arising from the respective mesodermal tissues. Surgical treatment is indicated when they produce symptoms. These tumors will not transmit light and can be differentiated from varicosities since they cannot be reduced in size and do not give an impulse on a sudden strain but they have the consistency of the usual fibroma or lipoma.

4 Mammary Tissue — Aberrant or accessory mammary tissue may be found near the mons veneris. We removed from one patient two masses of tissue, one on each side of the clitoris which microscopically proved to be mammary tissue. The patient had noted changes in these two masses like those of the normal breasts. It may be necessary in removing such mammary tissue to remove the clitoris but ordinarily this is unnecessary. A biopsy might be taken but usually these small sites are better managed by complete removal for the process might be malignant. If a biopsy is taken and mammary tissue is found removal is advised. X-ray treatment should not be used more over it might interfere with the normal sensory nerves to the vulva area and possibly contribute to loss of libido.

5 Endometriosis — In infrequent instances endometrial tissue has been found in the inguinal canal which may descend down to the labia majora. Endometriosis on the other hand may by one or another means arrive on the vulva and present the picture of a dark violaceous growth. Biopsy would reveal the typical pattern of endometriosis. Endometriosis if it is diffuse and general and elsewhere about the pelvis may need to be treated by castration. Local processes can be individually treated. Castration may

be accomplished by bilateral oophorectomy or by deep x ray therapy. The clinical situation should dictate the type of treatment. (See section on Endometriosis.)

**6 Cysts of the Canal of Nuck**—Cysts of the canal of Nuck are quite rare. They may be unilateral or bilateral and may be multiple but are not necessarily so. Treatment consists of extirpation. They may be found in the inguinal canal, mons veneris or even the labia but usually are above the level of the mons veneris.

### MALIGNANT NEOPLASMS

**1 Carcinoma**—Primary carcinoma of the vulva may arise either from the epithelium of the vulva or from the glands of the epidermis. Taussig claims the average age is 60 and that approximately 4 per cent of all gynecologic cancers arise from the vulva. The growth may arise also from the glans of the clitoris. There are occasional reports of carcinoma of Bartholin's gland. Carcinoma has been a frequent successor to kraurosis or atrophic vulvitis. Details of the histopathologic descriptions of vulvar malignant growths may be found in standard text books and in the current gynecologic literature. Taussig has made an extensive study of this subject. It is generally conceded that deep x ray and radium treatment are unsatisfactory from a therapeutic viewpoint. Surgical removal of the vulva is indicated, according to Taussig and others. The malignant tissue must all be completely removed. If the lesion is at all advanced the chance of complete removal is only slight. As metastasis occurs quite early, Taussig recommends removal of the inguinal and femoral glands either at the same time as radical vulvectomy or as a second stage operation. He advocates his modification of the Basset technique. Taussig says:

In the technique of operation it must be borne in mind that the complete operation consisting of bilateral removal of the lymph glands and complete vulvectomy is a procedure that requires about two hours time and should therefore not be employed as a one-stage measure except in a relatively early case with the patient in good physical condition. A two-stage removal is preferable: the second operation following about two or three weeks after the first. If the ulcerative process in the vulva is advanced vulvectomy should be accomplished first and gland removal later. In earlier cases this procedure may be reversed. In very old women who are poor operative risks one must

at times be satisfied with a simple vulvectomy. Local anesthesia preceded by twilight sleep is satisfactory and does not materially interfere with wound healing. The operative mortality is about 5 per cent.

The writer's modification of Basset's original technique consists of an incision 6 inches long extending from a point 1 inch internal to the anterior superior spine down over Scarpa's triangle. The entire inguinal canal is then opened up from the external to the internal ring and the internal oblique muscle pulled upward exposing the deep epigastric vessels at their point of origin from the external iliac vessels. After these vessels have been doubly ligated and cut the space on either side of the external iliac vessels is opened up and the lymph glands in this area are separately removed. Then the entire chain of superficial inguinal and femoral lymphatics including the tissue of Scarpa's triangle is freed and lifted up. The saphenous vein is cut and ligated close to the femoral and if necessary Poupert's ligament is cut over the femoral ring to permit the more complete removal of the lymph gland of Cloquet situated just above the ring. Closure of the inguinal canal and the wound is accomplished in the usual manner with a drain through a separate stab wound over Scarpa's triangle.

	Number		Percentage
	Cases	Survival	Survival
Basset and vulvectomy	41	24	58.5
Superficial or incomplete gland removal and vulvectomy	21	6	28.6
Vulvectomy only	12	1	8
Radiation treatment	21	1	4.8
Palliative measures (no excision or radiation)	6	0	0.0
Total	101	32	32.0

A malignant growth arising from the clitoris may be more extensive and may spread more rapidly than the usual basal epidermal growth. A malignant growth arising from the glands likewise may spread more rapidly. A malignant growth from the urethra may extend out on to the vulva obscuring the primary site. The use of x ray treatment subsequent to surgical removal has been recommended by some.

**2 Sarcoma**—Sarcoma of the vulva is quite rare but theoretically could develop just as it does in any other site of the body. Its treatment must be individually considered.

**3 Metastatic Lesions**—The presence of metastatic lesions indicates the advanced growth of a primary tumor. Surgical removal of metastatic lesions should be done only for symptomatic relief, certainly not as a curative process. Radium may be used on metastatic lesions depending upon their

site and the type of malignant growth. These lesions may result from implants or metastasis from carcinoma of the cervix or uterus or other organs or rarely from malignant hemangioma.

**Chorioepithelioma** involving the vulva indicates a metastatic lesion. Therapy should be directed principally toward the primary site which would be almost always the uterus. Surgical removal or adequate x-ray therapy to the uterus and also to the local lesion should offer the best prognosis. Removal of the uterus is advised by most obstetricians and gynecologists.

**4 Malignant Melanoma**—This condition is of rare occurrence.

### MISCELLANEOUS CONDITIONS

**1 Varicosities**—Varicosities of the vulva are moderately common. They are associated frequently with vaginal varicosities and usually occur in women who have varicosities of the legs and rectum. The labia majora are normally vascular but become more vascular as varicosities develop. The surface is irregular owing to the distention of the veins. Women tend to have a sense of tiredness or heaviness if they are on their feet a great deal because of the stasis and distention. The pregnant state and pelvic tumors or masses accentuate varicosities and increase the amount of venous involvement. Ordinarily varicosities of the vulva do not need surgical attention. In the event that their size and condition justify surgical intervention, ligation of the individual vessels in a very vascular area is carried out. Severe blood loss can occur during surgical procedures upon the vulva.

**2 Hematoma**—Hematoma of the vulva may occur as the result of trauma during delivery or resulting from a fall upon an object or from an automobile or bicycle accident. The broken blood vessel should be isolated and ligated, the clot evacuated and the wound closed tightly. If the hematoma is old and uncomplicated, one may observe the state for several days. An uninfected clot will be absorbed. If the hematoma is infected, adequate incision and drainage is indicated.

**3 Wounds**—Wounds of the vulva are uncommon but do occur. The nature of the injury will determine the procedure at the

time. Women in combat zone areas may suffer vulvar injury from explosives. If the wound is relatively clean, the control of bleeding, debridement and closure may be sufficient. If the wound is badly contaminated it may be advisable to approximate the edges but allow for drainage after the control of bleeding and the debridement have been completed. The use of tetanus antitoxin must be given consideration in each instance of injury, depending upon the cause of injury and other factors. Individuals injured on the bridge path or in the riding stable or around gunfire or ammunition should receive tetanus antitoxin. Sulfanilamide or one of the other sulfonamides may be placed in the wound. Cultures should be taken at the time of the initial treatment to insure appropriate therapy in the event that an infection becomes active.

**4 Pruritus**—Irritation of the vulva is fairly frequent in association with urethral and bladder lesions and occasionally in association with cervicitis or vaginitis. The treatment should be directed at the principal cause using only sufficient local therapy for symptomatic relief. Surgical treatment is contraindicated. Certain urethral lesions or bladder conditions may cause severe pruritus. Occasionally, if there is poor anal hygiene or an injured anal sphincter, vulvitis may develop secondarily.

**5 Fistulas**—Fistulas of several types may involve the vulva. Therapy should be directed at eradication of the fistulous tract. It may be necessary, if it connects with the rectum near the sphincter, to lay the sinus open completely, allowing the wound to heal by granulation. If the fistula connects only with the vagina, it may not require attention.

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## CONGENITAL MALFORMATIONS OF THE VAGINA, UTERUS, OVARIES AND TUBES

In general the abnormalities of development of the ovaries are due to interference with the development of the genital ridge and its surrounding epithelium and non-descent to lack of the proper position of the gubernaculum. Malformations of the vagina, cervix and tubes may be due to improper canalization of the müllerian ducts or improper fusion of the distal ends of the ducts in the region of the urogenital mass or lack of absorption of septa after fusion. Lack of proper alignment of the tubal portions of the ducts will prevent proper development of the fundus and body of the uterus.

**The Vagina**—Congenital malformations of the vagina are due to non union or incomplete fusion of the müllerian ducts or to lack of removal or incomplete removal of the septa after they have been united.

**Absence of the vagina** is due to the failure of the fused ducts to canalize and atresia is due to improper canalization of the ducts. With absence or atresia of the vagina the uterus is usually functionless and hematometra is rare. Secondary sex characteristics are usually properly developed and the desire for marriage is normal. In such cases reconstruction of the vagina may be necessary.

**Double vagina** occurs because the septum formed by the fusion of the two ducts has not been absorbed. The septum may extend as far as the hymen and to the vaginal fornix. It divides the vagina into two equal or unequal parts and two cervixes are always present. Removal of the septum is not difficult and may be performed in order to enlarge the orifice to aid conception or to avoid tears at delivery. A double uterus nearly always occurs when there is a double vagina and cervix. Atresia of one half of a double vagina is possible and unilateral

hematocolpos, hematosalpinx and hematometra are not unknown. Transverse septa do occur but are not usual.

**Imperforate hymen** is due to a lack of breaking down of the septum which shuts the uterovaginal canal off from the urogenital sinus or to a growth of a new diaphragm. This defect may result in an accumulation of mucus behind the septum in the infant or very young child and later after menstruation has commenced hematocolpos, hematometra and hematosalpinx. The treatment is incision of the hymen with perfect asepsis as infection occurs easily. When the hymen is imperforate and the internal genitals are small there may be no vagina.

**The clitoris** arises from the genital tubercle near the urogenital orifice and is analogous to the penis. Hypertrophy is noted as a masculine characteristic of pseudohermaphrodites. Hypertrophy is also present as an evidence of masculinization in adrenal cortex overactivity and in the presence of in ovotestis, testicular tubular adenoma of Pick or arrhenoblastoma of the ovary. Absence of the clitoris is rare.

**Hypospadias** is a lack of closure of the posterior wall of the urethra caused by lack of development of the urethrovaginal septum.

**Epispadias** is due to the defective formation of the anterior wall of the urethra and may be accompanied by separation of the pubic bones and lack of closure of part of the anterior abdominal and bladder walls (exstrophy).

**The Uterus**—Congenital abnormalities of the uterus are due to complete or partial failure of fusion of the two müllerian ducts or to lack of development of the tissue (mesenchyme) about the two uterine ends of the early fallopian tubes above the cranial end of the uterovaginal canal. Complete absence of the uterus is not found except in extreme maldevelopment of the embryo for even when the vagina is absent, a small rudimentary cord of uterine tissue can be found. A third uterus is possible but extremely rare. One such case has been reported.

More common uterine abnormalities are the following:

**I Uterus didelphys**—double uterus, double cervix and double vagina. This is

rare and most often noted in a non viable monster. It is due to failure of fusion of the mullerian ducts.

2 Uterus duplex bicornis—double uterus with joined cervixes but separate canals and double or single vagina. This type is not uncommon and is due to complete or partial failure of union of the mullerian ducts.

3 Uterus bicornis unicollis—double uterus with single cervix and vagina. It is due to partial fusion of the mullerian ducts or to lack of proper alignment of the tubal portions of the ducts in the region of development of the body and fundus.

4 Uterus arcuatus—a slight depression in the exterior of the fundus which is due to lack of proper development of the body and fundus around the uterine ends of the tubes and upper end of the uterovaginal canal.

5 Uterus bicornis septus—normal appearing uterus or with a slightly depressed fundus but with a septum from fundus to external os. It is due to lack of absorption of the uterine and cervical septa. The vagina is single.

6 Uterus septus duplex cum vagina septa—a uterus with an anteroposterior septum and a vagina divided by a septum. This is due to lack of absorption of the septa.

7 Uterus biforus—normal uterus with a double cervical orifice. This is due to lack of absorption of the cervical septum.

8 Uterus unicornis—one half of a normal uterus. This is due to absence or aplasia of one mullerian duct.

9 Uterus bicornis cum rudimento cornu alterius—nearly normal uterus with a rudimentary horn. This is the deformity of the most practical importance. At the extremity of the rudimentary horn the fallopian tube and round ligament are attached. The cavity of the horn may be complete or partial. Infection or pregnancy is possible in the rudimentary horn. Diagnosis may be difficult.

These nine types are the most important developmental abnormalities. No treatment is necessary until some difficulty arises as both uteri or only one may function properly. Pregnancy can take place in either but activity is usually greater on one side. Atresia of one vagina or one cervix may cause difficulty and various diagnostic possibilities must be considered. The extra

uterus or the rudimentary horn can be removed but a developmental defect is not *per se* an indication for operation.

**The Ovary**—Bilateral absence of the ovaries is extremely rare and probably occurs only in non viable monsters. Unilateral absence of the ovary may take place when one mullerian duct is absent. There may also be absence of the tube and the uterus should be unicorn. It is conceivable that in fetal life one ovary might be twisted off. Supernumerary ovaries are occasionally seen and are usually near the normal ovarian site or are found on the posterior abdominal wall. A third ovary is a rarity. A tube or utero-ovarian ligament must be present. A third or supernumerary ovary probably explains the occurrence of menstruation or of pregnancy after bilateral oophorectomy. An ovary is not uncommonly found in the inguinal canal during an operation for hernia.

Ovotestis a combination of ovary and testicle is very rare and is a form of masculinization.

**The Tube**—Bilateral absence of the tubes is chiefly found in non viable monsters. Unilateral absence of the tube may occur with absence of one ovary and is due to absence or aplasia of one mullerian duct. Accessory tubes are not uncommon and occur as double ostia or as diverticula of the side of the tubal wall. Extrauterine pregnancy may occur in these tubes. Third tubes are rare and are seen in association with true third ovaries. Unilateral defects such as atresia can occur as a result of lack of canalization of the mullerian duct.

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## URETHRAL CARUNCLE

**Definition**—Urethral caruncle or caruncle, also known as irritable caruncle or urethral angioma, is a true benign neoplasm. It may be the size of a pinhead or of the little finger and is usually found at the external orifice of the urethra on the posterior wall, usually in the lower third. It may be sessile or pedunculated, with a small or broad base and a thin or thick pedicle. It is usually a dusky dark red but occasionally bright red. It is usually single but may be multiple and is seen most frequently about the menopause.

**Etiology**—The etiology is not clear but parturitional trauma and infection or gonorrhea and inflammation of Skene's glands may be considered.

**Pathology**—According to Frank there are three types of caruncles—the granulomatous, the papillary angiomatous and the telangiectatic or blood vessel type.

**Symptomatology**—Interference with the function of the urethra may cause great distress. Dysuria and frequency are very common and hematuria, urinary retention and incontinence occur. The patient may be distressed and anxious and often a severe neurosis develops. Dyspareunia and bleeding add to the discomfort of the patient. The symptoms may last for from ten to twenty years and many unsuccessful attempts may have been made to treat the condition.

**Diagnosis**—Prolapse of the urethra is frequently confused with caruncle and it is sometimes difficult to distinguish between them. Varicosities of the urethra, polyp of the urethra, condyloma, cysts of Skene's glands, myoma, fibromyoma, sarcoma and carcinoma as well as adenoma and nevus both pigmented and non-pigmented must be differentiated. The caruncle is not always visible; a small hair pin speculum may be necessary to visualize the upper part of the lower urethra. Cystitis may clear up after removal of the hidden caruncle.

**Prognosis**—Complete excision is the only cure and as this is extremely difficult the prognosis is not good. The tumor infiltrates and recurs easily. Malignant changes are rare but have been known to occur.

**Treatment**—Radical excision is best. DeMeigs suggests circumcision of the urethra

with suture of the urethral mucous membrane to the vaginal mucous membrane. Deep coagulation with the endotherm reported if necessary is an excellent method. Simple excision is rarely sufficient. The actual cautery or silver nitrate usually fails. Radium occasionally gives a good result but is not advised.

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## VAGINAL FISTULA

### VESICOVAGINAL FISTULA

Vesicovaginal fistula is a surgical entity that has developed as a complication subsequent to surgical procedures on the pelvic structures, difficult and complicated deliveries, radiation therapy for carcinoma of the cervix or accidental trauma. The greatest number of these fistulas in more recent years fall in the first group but there have been some from each group. The surgical problems involved in the treatment of vesicovaginal fistula require considerable thought, complete urologic investigation and a working knowledge of the various surgical procedures that are known and that have proved to give the best results for different types of fistula. There is not just one operation or one method of approach that is applicable to all vesicovaginal fistulas. The number of fistulas secondary to surgical procedures on the pelvic structures and vaginal plastic operations is definitely greater than in previous years. Vesicovaginal fistulas are rarely produced by granulomatous disease.

**Diagnosis**—The diagnosis of a urinary fistula is usually evident from the leakage of urine, excoriation of the labia, inflammation

tion of the vagina and the odor but to locate a small fistula may be extremely difficult. Accurate information as to how the fistula occurred in the first place is most important. A large opening can be easily seen and felt by the examining finger. A fistula 1 or 2 mm or less in diameter may have to be visualized by placing a colored solution in the bladder and noting its point of exit. However, accuracy in the location of the fistula or fistulas is so important that very careful cystoscopic examination is a prerequisite to the successful repair of the fistula. A fistula situated near the urethral sphincter or near the ureteral meatus is more difficult to handle surgically than one situated elsewhere in the bladder.

Any complications involving the upper part of the urinary tract must be excluded. A fistula may involve a ureter and may be followed by hydronephrosis or a functionless kidney on the involved side. A fistula situated high on either side of the vaginal vault may be a ureterovaginal fistula instead of a vesicovaginal fistula. These facts should be determined prior to surgical treatment. At the time of cystoscopic examination the extent of any inflammation of the vesical mucosa can be determined and appropriate measures taken to eliminate it before surgical treatment is instituted.

**Treatment**—There is much that can be said regarding the treatment of vesicovaginal fistulas but briefly there are certain conditions which are a prerequisite to successful closure. No surgical procedures should be undertaken until all evidence of infection of the bladder and any complicating condition of the upper part of the urinary tract have been eliminated. Spontaneous closure of a small fistula such as follows delivery is fairly common. It also is true that a small fistula that occurs high in the dome of the bladder following a surgical procedure has been observed to close spontaneously if the bladder is kept continuously empty by a retaining catheter for a few days. If such a fistula does not close early it will be useless to continue conservative management. Light cauterization of a small fistula or electrocoagulation of a pin-point fistula may result in closure. This type of treatment should be limited to small fistulas of the recurring type.

Most fistulas make their appearance a few days subsequent to operation as a direct result of necrosis. In inflamed tissue immediate surgical repair is likely to result in a high incidence of failures; therefore it is advisable to postpone surgical repair for six weeks to three months in order that all edema and other evidence of inflammation may subside completely. Failure to observe this rule is one of the greatest causes of recurrence of the fistula. Furthermore if recurrence follows what seems to be an excellent closure it is best not to touch the fistula again for several weeks.

These fistulas may be repaired by the vaginal route or by the transvesical route. The vaginal approach carries less risk and offers a greater chance of success than any other approach. Accurate exposure can best be had with the patient in the Kraske position especially in cases in which the fistula occurs after total abdominal hysterectomy. All scar tissue around the fistula should be excised completely. This is best accomplished by incising the vaginal wall adequately behind and in front of the fistula. The incision should surround the opening of the fistula and sufficient scar should be left attached to the fistula to pull the scar upward into the vagina. The vaginal wall is dissected away from the bladder for 1.5 cm on each side of the fistula. When the scar is excised from the fistula it will always be much larger than it originally seemed to be. The fistula is then closed with three rows of catgut sutures in the bladder wall. Each row is continuous; the first one consists of no. 000 chromic catgut and just approximates the mucous membrane of the bladder without a suture passing through it. The second row of sutures consists of no. 00 chromic catgut; it begins 1 cm beyond the original row of sutures and extends 1 cm beyond where the previous one ended. The third row of sutures is placed in the wall of the bladder and consists of no. 0 chromic catgut. It begins 1 cm beyond the second row of sutures and ends 1 cm beyond the end of the second row. There must be no dead space between any of the suture lines. In other words the anastomosis should be done exactly as an intestinal anastomosis. Purse-string sutures should not be employed. I would not advise the use of non-

absorbable sutures in the vesical wall. The vaginal wall should be closed with interrupted sutures preferably of cotton or silk. Each suture should incorporate some of the vesical wall so as to hold the vaginal wall and vesical wall firmly together. All bleeding should be completely controlled.

**Postoperative Care**—The best results are obtained by keeping the patient on a Bradford frame although this is not compulsory. An indwelling straight catheter should be kept in place from ten to fourteen days and the vesical urine should be kept slightly acid by the administration of small doses of ammonium mandelate. Any vaginal examination should be absolutely prohibited for at least three weeks. Only harm can result from placing a speculum in the vagina during the period of healing. The non-absorbable sutures should be removed in four to six weeks.

### RECTOVAGINAL FISTULA

There are five types of rectovaginal fistula, namely, (1) that which develops subsequent to repair of complete laceration of the perineum (2) that which occurs simultaneously with vesicovaginal fistula (3) that which arises insidiously and in conjunction with an abscess in an anal crypt (4) that due to direct violence or an ill fitting pessary and (5) that which arises from granulomatous disease or malignant disease.

**Diagnosis**—Escape of gas and feces into the vagina is usually diagnostic of a communication between these two cavities. It is caused either by trauma or by disease.

**Treatment**—An inguinal colostomy as a preliminary procedure in a case of large rectovaginal fistula particularly when the fistula is situated high in the rectovaginal septum may be a distinct advantage. Also it should be considered in cases in which repeated operations have been performed to close the fistula. In cases in which the fistula is tuberculous syphilitic or due to an ulcerating carcinoma a permanent colostomy is probably the only procedure advisable. Unlike a vesicovaginal fistula a rectovaginal fistula rarely heals spontaneously and seldom can be closed successfully by coagulation or cauterization.

The cause of failure in the treatment of rectovaginal fistulas is due to infection the

lack of blood supply and tension. A small fistula that occurs with an intact perineum and anal sphincter is probably the most difficult to treat satisfactorily; the closer the fistula is to the perineal body the greater the hazard of recurrence. In these cases the anal sphincter should be kept constantly dilated for the escape of gas and feces for from ten days to two weeks.

Rectovaginal fistula incidental to incomplete healing of complete perineal laceration should be treated by complete division of the scar or the remaining portion of the perineum. The scar in the margin of the rectal wall should be excised completely. The anterior wall of the rectum should then be repaired in layers as far outward as its normal junction with the anus and sphincter muscles. The ends of the sphincter muscles should never be isolated from the scar but the scarred ends should be utilized to pull the sphincters together. The perineum is then repaired by the usual technique.

Failure to close a fistula of this type is usually due to pulling the rectal wall forward to meet the sphincters rather than repairing the anterior rectal wall in layers.

The most troublesome fistula is that which occurs after infection in an anal crypt. This type of fistula is rare nevertheless it does occur spontaneously and must be recognized. The cause of this type of fistula is the same as that of fistula in ano. Repair will never be successful until all evidence of infection from the anal crypt has been eliminated; therefore the fundamental principle in treatment is complete division of the fistulous tract including complete division of the sphincters and perineal body if necessary. After all infection has been eliminated and healing of the sinus tract is complete the perineum, anal sphincters and rectal wall should be repaired. Failure to observe these principles will invariably result in failure.

Enemas should not be given for ten days to two weeks after operation. Then only an oil retention enema should be given and retained overnight. The patient should be urged to evacuate the bowel without repeated enemas. Mineral oil given to maintain a soft stool is one of the most potent causes for recurrence of the fistula. An empty rectum or a dry stool in the rectum is most favorable.

VIRGIL S. COUNSELLER



## XXXVI. PLASTIC SURGERY

### GENERAL PRINCIPLES

Plastic surgery deals with the repair of congenital or acquired deformities for the improvement of appearance or function and occasionally for the relief of pain. This repair is usually accomplished by means of an adjustment of tissues with or without the use of adjacent or of distant transplanted tissue. Plastic surgery overlaps general surgery and all the various special branches of surgery. Mechanical appliances or prostheses may be employed either alone or in conjunction with it.

Congenital malformations arise from embryonic maldevelopment or intrauterine disease such as syphilis. After birth deformities are acquired as a result of disease or trauma or a combination of the two. The trauma may be accidental or intentional as from surgical operations.

Usually the tissues involved are on the external surfaces of the body but deeper tissues also may be affected. The degree of deformity depends on the location as well as the extent of the lesion.

A thorough knowledge of the tissues involved and of the principles of wound healing are required of the surgeon and he must know the operations that have been evolved and be able to adapt them or to devise special procedures to fit particular circumstances. It is important to diagnose where misplaced tissues originally belonged or what alterations from the normal have occurred and also to determine what must be done to correct these conditions.

As there is a choice of procedures which can be used in the repair of any deformity the surgeon should suit the method to the individual case taking into consideration the costliness, the length of time available and the patient's temperament, age and physical condition. All of the factors should be weighed and advice should be given against an operation that offers a considerable chance either of not succeeding or of adding undue deformity. It is often easier to satisfy a patient who has a marked de-

formity than one with nearly perfect features.

Plastic operations should never be performed in the presence of infection except when absolutely necessary; provision should then be made to combat it by adequate measures. As most plastic procedures are elective conditions for operation should be as nearly ideal as possible; not only should the general health of the patient be satisfactory but local suppurative processes such as acne, pustules, boils, etc. should be absent. Infection may detract considerably from an otherwise satisfactory final result and may even cause complete failure.

In cases of emergency, various conditions such as infection, fracture, subdural hemorrhage, shock, etc. may frequently demand treatment before any plastic procedure can be carried out. If possible the plastic surgeon should perform the first emergency repair since the secondary repair of deformities may be rendered more difficult because of improper repair at the first operation.

In general transplanted tissue should resemble the tissue it replaces as closely as possible. On the face the skin varies in thickness, color, texture, hairiness and tension. All of these factors should be considered in selecting the donor tissue.

Plastic surgery is a type of sculpture in which living tissues are used. These tissues require nourishment or they will die. A satisfactory blood supply—venous as well as arterial—must be maintained to the part. Frequently an otherwise well performed procedure may fail because of disregard for the proper amount of pressure maintained in the dressings so as to prevent passive congestion. Pressure also aids in controlling hemorrhage and in approximating raw surfaces.

Careful hemostasis, use of the finest needles and suture material and gentle handling of tissues are essential for the best results. Buried sutures take the burden of tension from the skin sutures and allow the early removal of the latter so that they leave no scars. Constriction of the skin by sutures causes necrosis and necrosis means scarring.

and deformity. The more loosely the skin sutures can be tied, in conformance with good approximation of the cut surfaces, and the earlier they are removed, the smaller will be their permanent mark on the skin.

Postoperative care, both in the dressing at operation and subsequently, is most important. These dressings, if at all complicated should be taken care of by someone capable of handling all contingencies that may arise.

Reparative processes in wounds continue for months and even years, and grafts which are not entirely satisfactory at the end of a few months may be vastly improved at the end of two or three years.

#### CLOSURE OF DEFECTS; TISSUE SHIFTING AND ROTATION; PEDICLE FLAPS

After excision of a scar or some other superficial pathologic lesion, the resultant defect may often be closed by bringing to-

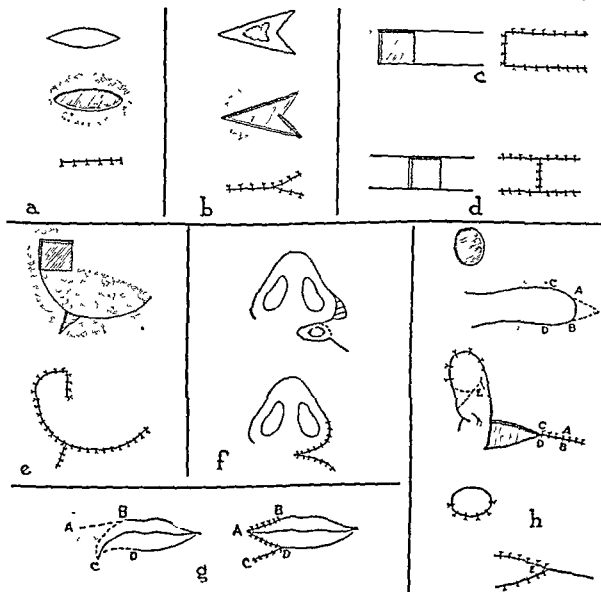


Fig. 701—*a*, Elliptical incision which can, after undermining be closed in a straight line. This procedure is extremely useful and the long axis of the ellipse should be in the most favorable direction of skin tension. *b*, excision of a lesion with closure in the form of a Y. *c*, schematic drawing of closure of a square defect by advancing or shifting skin and subcutaneous tissue from one side. *d*, closure of defect by advancing skin and subcutaneous tissue from both sides of a square defect. *e*, closure of a square defect by rotation of the skin and subcutaneous tissue. Note the relatively large scar. *f*, closure of a defect after excising a lesion on the upper lip below the nostril. Tissue is advanced from the cheek. Simple closure would result in distortion of the lip or nose. *g*, Z incision for correction of a displaced commissure of the mouth with transposition of flaps A, B, C, and D. *h*, closure of defect by simple pedicle flap with return of pedicle to the donor bed after the flap has been severed.

gether adjacent tissues. Simple approximation of the skin edges by sutures, however, may not suffice because any excessive tension gives rise to subsequent spreading of the scar. The connective tissue trabeculae in the adjacent subcutaneous tissue—whereby the skin is attached to deeper structures—

tissue may, however, be incised upward from the depths of the undercut tissue to the skin to allow further relaxation without subsequent visible scarring of the skin.

An elliptical skin incision encompassing the tissue to be excised with the aid of undercutting should leave an inconspicuous

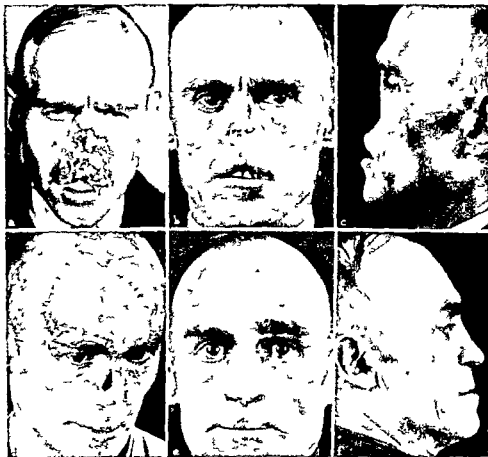


Fig. 703.—Total rhinoplasty. *a*, Active syphilitic lesion of the nose and lip. *b*, result after treating following antiluetic treatment. Note the loss of the nose. *c*, same stage as *b*, profile view. *d*, a delayed pedicle flap on the forehead in the first stage after an opening has been made into the nasal cavity and after the lip has been drawn downward. The flap has been raised and a full thickness graft from the arm has been laid across the middle of the flap with the skin surface down so as to form a lining of the new nose according to New's technique. The flap was later raised and the distal end was folded on itself to form the columella and the two alae and was sutured to the full thickness graft. It was then rotated downward to form the new nose. The major portion of the defect of the forehead was covered with a full thickness graft. *e*, end result. The flap has been severed and the pedicle returned to its former bed. The full thickness skin graft to the forehead is seen. A cartilage graft from the rib has been inserted to build up the bridge and two cartilage grafts have been inserted to maintain the normal shape of the columella and alae. *f*, end result, profile view.

may be severed by undercutting and this provided a sufficient blood supply to the skin is maintained, will permit stretching of the skin and relief of tension so as to allow closure with sutures. No relaxing incisions through the skin at a distance from the wound should be required after sufficient undercutting, the undermined subcutaneous

linear scar if closed in the most favorable direction of skin tension (Fig. 704 *a*). This method of excising small lesions is one of the most useful and satisfactory procedures because it is the simplest and produces a minimum of deformity.

Although many complicated closures of defects have been devised and may be used

Fig 704 a to g) the simpler the method employed the better Incisions radiating from a defect into the healthy tissue permit

completion in one stage Many defects caused by trauma or disease as well as by operation can be treated in this way



Fig 706—a Squamous cell epithelioma of the ear involving the anterior and posterior surfaces of the helix. (a) Control showing the defect in the earle following radical excision of the tumor. (b) Closure of the defect by means of a delayed flap. (c) The skin flap lined with a full thickness skin graft from the arm. (d) The skin surface donor site. (e) The flap is free graft sutured in place. The flap is anagkn on both surfaces was raised and the defect closed. (f) Another full thickness skin graft. It is possible to suture off the thickness raised and the defect closed. (g) Another full thickness skin graft. When the latter is sutured and a final result after suturing the flap in place and using a partial unrolled tubular pedicle skin flap from the neck to form the new helix. All operations except the primary excision of the lesion are performed under local anesthesia.

flaps of skin and subcutaneous tissue which have been judiciously undermined to be advanced shifted or rotated into the defect from the adjacent tissue closure is thus ac-

A flap of skin and subcutaneous tissue attached by a pedicle for nourishment may be shifted over an intervening space of skin to fill a defect (Fig 704 h). This is termed

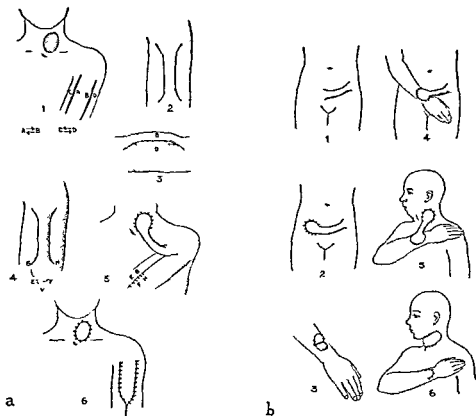


Fig 707—*a* Method of making a tubed pedicle skin flap on the arm attached to a defect on the neck and replacing the pedicle 1, Parallel incisions on the arm The tube is formed by approximating the skin edges *A* to *B* about the subcutaneous tissue with the skin covering the tube Closure is made by drawing skin edges *C* and *D* together 2 The skin tube from above 3 The skin tube from the side showing closure 4 Showing out line of flap *GHI* to be raised and skin *EF*, to be excised 5 The flap is transplanted into the defect on the neck and closure of the denuded area is completed after undermining 6 Division of the flap and replacement of the pedicle on the arm

*b* A delayed tubed pedicle flap from the abdomen to the neck—caterpillared by an intermediate stage to the forearm 1 Formation of tubed pedicle 2 Delaying the flap by raising it and suturing it back in place 3 Raising of a flap on the forearm By such a flap a bed of twice the size of the tissue included in the incision is made available for nourishment 4 The tubed flap attached to the forearm flap 5 The pedicle flap of the iliac region attached to a defect on the neck 6 The remainder of the neck contracture is excised and the defect covered by the unrolled pedicle flap The forearm flap has been returned to its normal position



Fig 708—*a* Fistula of the nose and cheek from operative approach to infected vascular tumor of the nares Note the wide defect showing the inner nasal cavity A delayed thoracoepigastric tubed pedicle flap has been made A full thickness skin graft from the arm has been transplanted to the under surface of the flap and the flap has been freed except for four points of attachment The defect on the arm has been covered by a thick split skin graft from the thigh *b* profile view showing the closure of the defect

a *pedicle skin flap* The transplanted flap eventually receives sufficient nourishment from its new bed to be independent of the pedicle. The flap may then be severed from the pedicle and shaped to fit the defect and the pedicle may be excised or returned to its original donor bed. It is evident that at least two operations are required for repairing a defect with the ordinary pedicle skin flap.

After a flap has formed its new attachment there may be enough blood supply by a reversed flow to nourish the entire pedicle when severed at its base. The freshly severed base or the entire pedicle may then be attached to another defect. When the two ends are used alternately as points of attachment

portion may be sutured back in its bed and subsequently shifted. This is termed a *delayed flap*.

To avoid the usual infection of the raw surface of the simple pedicle flap and also to increase the vascularization Gillies<sup>3</sup> devised the *tubed pedicle flap*. At the first operation a closed tubed pedicle is formed similar to a suitcase handle by undermining between parallel incisions and suturing the inner skin edges together with the surface skin outside. The lateral skin edges are approximated after undercutting or the bed is grafted so that no raw surface is left exposed to bacterial invasion. A flap at one end of this tubed pedicle with or without further de-

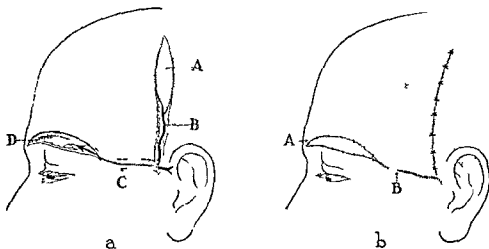


Fig. 79—Schematic illustrating of island flap from scalp to forehead repair of facial flap (flap A) artery (A) vein (C) tunnel made in the skin to permit translocation of flap (D) bed prepared to receive flap (E) Flap placed (F) Island flap in exposed forehead skin takes the place of absent eyebrow (B) new location of vessel in pedicle tunnel

so as to advance the pedicle flap by stages to a defect in another part of the body this is termed a *caterpillar* or *jumpy flap*. By making the intermediate attachment to an arm a great distance may be quickly covered by a comparatively short caterpillar pedicle flap.

In order to increase the vascular system in a pedicle flap before transferring it and so to insure against necrosis a portion of the flap or pedicle may be raised from its bed at a preliminary operation and subsequently after about ten days the entire pedicle flap may be raised and shifted. At the preliminary operation the undercut tissues may be kept apart by introducing a thin membrane or preferably to avoid infection the raised

living ear then be shifted more safely and more aseptically than in the simple pedicle flap. If a site is selected which embodies large vessels in the tube such as the thoracoepigastric vessels the blood supply is better assured and long tube may be made with out necrosis especially if a central skin attachment is temporarily retained.

The so called *island flap*<sup>4</sup> consists of skin and subcutaneous tissue with the pedicle comprising only the nutrient vessels and a minimum of surrounding tissue (Fig. 709). This flap is brought through a tunnel and sutured into the defect. The operation is completed in one stage. Its use is naturally limited to selected donor areas supplied with adequate blood vessels.

## FREE SKIN GRAFTS

Under favorable conditions many types of tissue completely freed from the rest of the body can be successfully transplanted. Free skin grafts are particularly useful for covering certain surface defects and three main varieties are generally employed.

*Small deep skin grafts* erroneously called pinch grafts may be used for covering healthy granulating surfaces. The original grafts of Reverdin<sup>8</sup> consisted entirely of epithelium but were not found to be as satisfactory as the small deep grafts which in addition to the epithelial layer contain nearly the entire depth of the derma. The skin is picked up with a needle and freed with a sharp scalpel or razor and the grafts from 0.6 to 0.9 cm. in diameter are transplanted to the granulations with their cen-

skin by collodion. Care must be taken not to allow the granulations between the grafts to grow above the level of the epithelium as spreading of the latter will be hindered or prevented. The judicious use of a silver nitrate stick or of curved scissors may be necessary to reduce the granulations. The healed grafted area contracts markedly and has a somewhat pebbled appearance but this becomes less conspicuous with time.

Sheets of split skin grafts (Fig. 710) may be skived free with a long knife or razor and are usually taken from the thigh, the abdomen, the back or the arm. During the removal the patient's skin is flattened out and stretched between a stationary straight edged object such as a thin board or square enameled dish and a similar object or a Blair suction box.<sup>9</sup> The latter is



Fig. 710—*a* Condition on admission twelve weeks after burn from gas stove. Note the excessively high granulations on the upper arm. *b* condition eight months after excision of granulation tissue and transplantation of thick split skin grafts.

ters about 1 or 1.5 cm. apart care being taken in the transfer not to contaminate the donor area. The intervening granulation spaces eventually become epithelized from the graft edges. The grafted area is dressed with overlapping strips of gutta serena or adhesive tape with vaselin gauze or better still xeroform gauze\* with compresses of physiologic saline solution or of a surgical solution of sodium hypochlorite which are frequently changed. The grafts may be held in place for three or four days by one layer of wide mesh gauze which is fastened to the surrounding

* Xeroform ointment	Gm.
B. Xeroform	3
Vaseline	95
Paraffin	1
Beeswax	1

Many layers of narrow mesh gauze in an oblong tin are saturated with the ointment and sterilized

made to withdraw progressively from the stationary object just ahead of the advancing knife. The first grafts of this type devised by Ollier<sup>10</sup> and Thiersch<sup>11</sup> contained only the epithelium but *thick split skin grafts*<sup>12</sup> containing nearly the whole thickness of the derma have proved to be more satisfactory. These grafts are particularly useful over freshly denuded areas and under proper conditions will grow over fat, fascia, ligaments, periosteum and even bare bone. Padgett's dermatome<sup>13</sup> used a new principle for the removal of thick split skin grafts. The instrument consists of a metal half drum with a 10 by 20 cm. curved surface. From it a sliding knife revolves over this surface and is adjusted by micrometer screws to cut at a determined distance from the curved surface of the drum. Rubber cement is spread

on the drum and on the skin and when these two surfaces become adherent by contact the skin can be pulled up and cut uniformly at any desired thickness. Parts of the trunk are thus made readily available as donor areas for skin grafts.

shiny or wrinkled appearance but the thicker the grafts are cut the more closely will they resemble normal skin.

Grafts of full thickness of skin (Wolfe-Krause grafts) if successful contract less and have a more natural appearance than

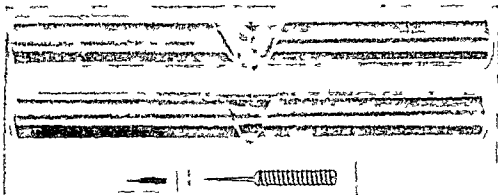


Fig 711—The author's skin rollers. The upper roller cut has a wide groove and the lower one a narrow groove for receiving the full thickness graft. The needle also at the bottom is adjustable and picks up the top of the full thickness graft and the skin is rolled up in the middle of the roller as it is dissected away.

With pressure dressings or with saline compresses granulating surfaces or freshly denuded areas even in the presence of infection as in the mouth or nose can be covered successfully by this type of graft. Wax molds fitting the defects and wrapped with these grafts may help to maintain the optimum pressure. Sterile sea sponges<sup>14</sup> volu-

the other types of free skin grafts. However it is more difficult to obtain success with them than with the other types. The graft of the desired size and pattern is removed with a minimum amount of subcutaneous fat. The use of the author's skin roller (Figs 711 and 712) facilitates this removal. The donor defect is closed by undercutting on either

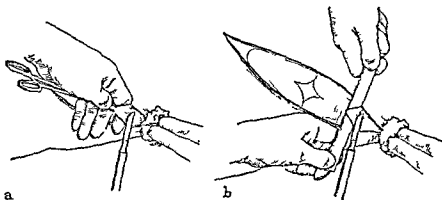


Fig 712—*a* Starting the removal of a full thickness graft. *b* The top of the graft has been caught on a needle and is being rolled on a metal roller. The roller can also be used for removing large nevi which do not extend beyond the depth of the skin.

minous fluffed gauze compresses or cotton waste placed over an immediate dressing of xeroform gauze is also used to obtain even pressure. These grafted areas may contract considerably and this property should be recognized and provision made for it by applying the grafts over a stretched denuded area. They may occasionally assume a dark

side and suturing or by split skin grafting and the full thickness graft is carefully sewn into the recipient defect. The graft should be equal to or slightly larger in size than the defect. An even satisfactory pressure must be maintained for a week or more with gauze or sea sponges over an immediate xeroform gauze dressing.



Free skin grafts folded with epithelium on the outside and wrapped in cellophane or phlofilm and then in vaselin gauze and sterile towels can be refrigerated at a temperature slightly above freezing and can be successfully transplanted days or even weeks later.<sup>18</sup> Prolonged operations can thus be divided into two shorter operations as a life saving measure an extra operation can be eliminated by this means and a piece of skin left over from an operation can be utilized later if occasion arises.

Free skin grafts may be transplanted from one individual (a) to the same individual (b) to another individual of the same species or (c) to another individual of a different species. These may be termed respectively (a) autografts (b) isografts and (c) zoo grafts.\*

Autografts under proper conditions should be uniformly successful. Although isografts have been reported as having taken successfully they usually fail to live more than a short time. Isografts of skin will often be apparently successful for as long as two to ten weeks and may then melt away. Sir Harold Gillies<sup>1</sup> reports the failure of a flap graft which had been transplanted from mother to child and had remained in position for a month. There is little hope of success with zoo grafts.

### GRAFTS OF OTHER TISSUES

Other types of tissue such as mucous membrane fat muscle fascia cartilage and bone can be successfully transplanted by means of flaps provided sufficient nourishment for the tissues is maintained for instance a portion of the clavicle can be raised and transplanted as part of a pedicle skin flap. Muscle can also be transplanted in like manner with a skin flap or by itself to fill a depression. These types of tissues can likewise be successfully transplanted as free autografts under favorable conditions.

Mucous membrane is rarely used for free

grafting because skin can be made to take its place in most instances but if employed it can be taken from the lower lip or cheek and treated as a split skin graft.<sup>18</sup> This tissue is more safely transplanted as a pedicle flap.

Free fat grafts are of great service in filling depressions. Dermal fat grafts whereby the lower portion of the skin together with the fat is transplanted or in the writer's hands fascial fat grafts with a sheet of fascia attached to the fat give a better chance of success than simple fat grafts. The lumbar region offers a satisfactory donor area for the fascial fat graft. Careful hemostasis gentle handling of the graft and freedom from infection are requisite in obtaining successful transplants.

Fascial grafts free from infection will take readily. They are useful for hernial repair either in strips as sutures in the Gallie Le Mesurier technique<sup>19</sup> or as broad sheets of tissue to be sewn into defects. This latter type is of great service in the repair of large ventral hernias and in the reconstruction of serous membranes. Fascial strips may also be used to bridge over gaps in tendons to repair chronic dislocations especially about the shoulder joint and to restore the muscles about the mouth to a normal position in cases of facial paralysis.<sup>20</sup> The fascial lata is the most frequent donor area and the lumbar fascia can also be used. With the use of a fascial stripper such as that of Grace<sup>21</sup> or of Masson long strips may be removed from the fascia lata through small incisions and in the writer's hands there has been no difficulty with herniation of the muscles of the thigh after removal by this method.

Tendon grafts may be successfully transplanted to replace gaps in tendons by using either whole tendons or portions of tendon. The palmaris longus tendon may be used with comparatively little functional damage and is often made to replace the flexor sublimis or flexor profundus digitorum tendons.<sup>22</sup>

Free muscle grafts are used in small pieces to stop hemorrhage but they do not live as large transplants since they cannot be sufficiently nourished. Such grafts become infiltrated with scar tissue if they do not become infected and extruded. Flaps of the masseter or temporal muscles are used to

\* Much confusion has arisen in the terms used to denote these three types of grafts namely (a) autoplastic grafts (b) isoplastic grafts (c) heteroplastic grafts. The writer has used the terminology of Dr. John Stace Davis in his *Plastic Surgery* as suggested by Dr. William H. Welch.

rectify paralysis of the muscles of the mouth and eyelids."<sup>1</sup>

Where there is loss of continuity in an important nerve such as the seventh cranial nerve the proximal end of other nerves the spinal accessory or hypoglossal may be transplanted into the distal end of the affected nerve. Very gentle handling of the nerve with fine sutures of arterial silk to the sheath should be used. The disadvantage of this procedure is that a fairly important nerve is destroyed and there may be failure of regeneration of the transplanted nerve. Patients sometimes complain of inability to use the newly attached nerve even though the tract has regenerated. A whole section of nerve can be successfully transplanted with regeneration of most of the fibers if an extremely careful technique is used. In this case the transplanted nerve probably acts only as a conductor for the growth of the nerve fibrils.

Veins may be transplanted as free grafts for the purpose of covering other structures for instance as tendon sheaths round transplanted tendons to the fingers. They are also sometimes used as conductors of nerve fibrils when gaps in nerves occur.

The ease with which cartilage can be carved into a desired shape makes it much more satisfactory than bone for filling certain depressions about the facial bones and skull. Depressions of the bridge of the nose caused by syphilis (Fig 705) or some other infection by accident or by operation may be filled out by cartilage grafts<sup>2</sup> after being carved to the proper shape and after the skin and subcutaneous tissue about the depression have been undercut (Fig 705 c f). The cartilage grafts may be introduced through an opening in the skin on the outside of the nose at its root or at the columella or through an opening made in the vestibule of the nostril after the skin and subcutaneous tissue have been undercut. Old depressed fractures of the maxilla malar bone or zygoma can be rendered normal in appearance by cartilage grafts. Cartilage for large defects may be removed from the ribs. The excess of cartilage removed can be buried in a subcutaneous pocket for future use or may be refrigerated. The somewhat more fibrous cartilage of the concha of the ear also can be used to build up smaller defects.

Cartilage preserved in mild antiseptic solutions such as merthiolate may be used either as autografts or as isografts to fill defects. There is some evidence to show that these grafts may eventually be replaced by fibrous tissue in contradistinction to fresh autografts and therefore might not be satisfactory when used for support. Dupertuis working in our clinic has shown experimentally that young cartilage transplants will grow either as autografts or as isografts in young animals and as isografts in adult animals but that adult cartilage will not grow in any case. From this it may be deduced that cartilage grafts for growing children if they are to keep pace with the rest of the body should be of young rather than of old cartilage.

Bone frequently with the periosteum attached is used extensively in orthopedic surgery as free grafts. In plastic surgery it is of use for filling defects especially of the facial bones and skull. It must be absolutely free from infection in order to take successfully and in order to remain without absorption it must be held in direct contact with bone preferably at each end. Bone grafts may be removed from the tibia the ribs or the crests of the ilium grafts from the ilium being especially useful to replace losses in the mandible.<sup>3</sup>

Successful free corneal isografts have been reported with maintenance of transparency<sup>4</sup> and with the recent development of a satisfactory technique they offer much hope for the restoration of sight to those with corneal scars.

## ULCERS

(See also Section on Indolent Ulcers)

An ulcer is an area on an epithelial surface with partial or complete erosion of the epithelium which may extend into the deeper tissues and is attended by more or less suppuration. A wound or superficial loss of tissue due to trauma is not primarily an ulcer but may become such if the healing process is arrested or if the wound becomes infected.

It is our purpose here to deal not with those ulcers of the skin which are usually managed by the dermatologist alone but with the indolent ulcers of the skin which can best be treated by means of plastic surgery.

Many factors may be responsible for the production of ulcers, and usually there are two or more factors working together. These cutaneous ulcers which fail to respond to the usual methods of treatment may occur in the presence of such constitutional disturbances as diabetes, arteriosclerosis, general debility, and various blood diseases. The long continued use of certain drugs (mercury, potassium iodide, etc.) and diets lacking in vitamins may be productive of ulceration.

Other, more local predisposing factors are vascular disturbances (varicose veins) and neurotrophic changes (syringomyelia and nerve paralysis). Scar tissue is prone to ulceration particularly when exposed to direct violence from without the part or from the repeated excessive stretching of contractions. Malignant disease, such as rodent ulcer (basal cell epithelioma) and squamous cell epithelioma, produce ulceration. Conversely, non-malignant ulcers of long standing frequently become epitheliomatous, probably because of constantly repeated irritation and the continued attempt of the part to heal by epithelial proliferation.

Trauma and infection are the most frequent exciting factors in the production of ulcers. Practically all ulcers of a chronic nature become infected either from without or from within the body by bacteria, fungi, or protozoa. When to the predisposing factor and the exciting factor, such as trauma, there is added the complication of infection the ulcer tends to become indolent and difficult to heal.

Sprochetes (syphilis and yaws) and acid-fast bacilli (tuberculosis and leprosy), coming from within the body, produce ulcers of the skin, and the presence of either type should be determined and treatment provided. Hemolytic streptococci from without the body may cause acute gangrene of the skin, resulting in chronic ulceration.

The wounds caused by burns, whether from heat, chemicals, electrical currents or irradiation, are particularly prone to become ulcerous and even malignant. In the first three of these types of burns there is an immediate wound which may be very extensive and deep and which may heal slowly, with scar tissue formation. In an irradiation burn the break in continuity of the surface may be long delayed after exposure to the rays—

even to as long as twenty years or more. There is a series of progressive changes in the skin and deeper structures, the main features of which are sclerosis and an avascularization of the part, culminating in ulceration and necrosis. The changes in the tissues may extend beyond and beneath the ulcer and so may render difficult the spontaneous and induced healing.

In the treatment of these conditions all of the predisposing factors should be counteracted as well as possible. Diabetes should be controlled with insulin and diet, the person with general debility should be built up, if there is anemia transfusions may be indicated, varicose veins should be treated by sclerosing fluids (quinine and urethane) or by ligation.

In decubitus ulcers due to pressure the skin overlying the bony prominences should be protected from pressure by the use of rubber rings, doughnut rings of cotton and bandages and by frequently turning the patient in bed.

The ulcerated extremity should be elevated in order to produce an increased blood supply to the part. A moderate heat is helpful and may be applied by light, such as "thermolite," or by a cradle supplied with electric light bulbs. Care should be taken not to apply too much heat so as to increase the ulcerative process. Chemotherapeutic drugs of the sulfonamide group given internally or externally or by both methods may control the infection. Penicillin may be useful. Many organisms in an ulcer, particularly anaerobic organisms, will clear up well with the use of zinc peroxide. This should be applied daily in the form of a thick creamy suspension of the powder in sterile distilled water and should be covered with vaselin gauze to prevent drying and caking of the medication.<sup>21</sup>

The ulcer itself should be carefully cleansed. It will be found that there is often a growth of epithelium about the edges of the ulcer, but between the granulations and the epithelium there is a re-entrant angle which harbors organisms and which prevents the epithelium from adhering to the granulations. For this reason the epithelium should be cut back and any tendency for it to roof-over should be counteracted. Compresses of physiologic saline solution applied so that they come in contact with every part

of the wound may stimulate granulations to grow up to the epithelium and give the latter a chance to grow over the granulations. Dressings of balsam of Peru and castor oil in equal parts help to stimulate the growth of granulation tissue. Some ulcers will heal if covered over with narrow strips of zinc oxide adhesive tape sterilized by heat leaving slight openings for drainage. Some of the sulfhydryl containing compounds such as thiocresol<sup>21</sup> cysteine hydrochloride<sup>22</sup> properly buffered to keep the solution in an even and proper hydrogen ion range oxyquinoline<sup>23</sup> and scarlet red<sup>24</sup> stimulate the growth of epithelium so that an ulcer may be healed by these measures alone.\*

Where the ulceration is progressive and is associated with a spreading zone of gangrene it is resistant to all the ordinary measures. A method of stopping the progress of this condition is to excise the diseased border with a wide margin. Meleney<sup>25</sup> has found that the progressive undermining ulceration without gangrene due to the microaerophilic hemolytic streptococcus can often be stopped by the use of zinc peroxide without requiring wide excision.

A chronic ulcer of long standing will have a base of dense scar tissue so that even if it has healed over it may break down again at the slightest trauma and the ulcerative process will be repeated.

The ulcers in the midst of scar tissue especially from thermal burns and those which resist the simpler therapeutic measures are best treated by wide and deep excision so as to leave only normal tissue at the base.<sup>21</sup> These ulcers for instance may extend completely around the lower part of the leg and it may seem very drastic to excise so widely. It will be a surprise however to see how universally these ulcers may be healed by such thorough excision and the immediate application of split skin grafts to the denuded area. It may in some cases be necessary to denude the tibia and such grafts as these will grow on the periosteum or even on the bone itself.

\* Oxyquinoline scarlet red gauze applied once or twice a day is helpful. It is made as follows: oxyquinoline sulfate 0.6 Gm. chlorotone (chlorobutanol) 2.4 Gm. liq. petrolatum 4 cc. scarlet red ointment 1 per cent to 1.0 Gm. Mix and then impregnate gauze with the mixture in a dry steril jar.

At operation there may be found to be a great difference in the level of the grafted area and that of the surrounding skin but in time there is a leveling process which makes for smoothness of the entire area. If the freshly grafted area is covered over with a single layer of wide-mesh gauze fastened down around the edges of normal skin with collodion and covered with compresses of physiologic saline solution changed every four hours these grafts should take despite infection. Most ulcers can be treated in this way with excellent success if less strenuous measures fail.

There are times when a thicker pad than a split skin graft is needed over the excised ulcerated area and pedicle flaps will be found preferable to the free skin grafts or the flaps may be transferred after free skin grafts have healed. In particular an ulcer of the sole of the foot where continual trauma may be expected can best be treated by a pedicle flap from the other leg—the two legs being held in proper position by means of plaster of paris casts. Wide excision of the scar tissue about these ulcers prevents further return of the ulcer after exposure to ordinary trauma. In selected cases an ulcer or scar over the tibia can be excised and the defect can be covered with healthy adjacent skin and subcutaneous tissue by making relaxing incisions parallel to and at a distance from one margin of the defect. By undermining over the deep fascia a pedicle flap attached proximally and distally can be swung over the tibia and sutured to the other edge of the defect and the lateral defect can then be closed with a split skin graft.

It will be found that many ulcers of a chronic nature which have eventually become malignant do not extend below the superficial layer of the deep fascia and can be readily stripped off with a wide margin of uninvolved tissue about the ulcer to assure safety. However a biopsy should first be made in order to determine the activity, type and grade of the epithelioma. It may be advisable to remove the lymph glands to which the malignant ulcer drains. The denuded area left by excision of the malignant ulcer can be covered by a split skin graft or pedicle flap. If thorough care is taken to make a wide excision it may be

possible to eliminate completely the malignant growth in these slow growing ulcerations without having to resort to amputation of the part

### SCARS CONTRACTURES HYPERTROPHIC SCARS KELOIDS

Scars are produced in the process of healing of tissue injuries and result in deformities which may be unsightly if visible. When disfiguring they may cause mental distress and influence the activities of the bearer.

There are congenital scars and those which are caused during life by accident by dis-

sent and this loss prevents the normal lubrication of the skin. The connective tissue fibers of scar tissue are more dense and less elastic than the connective tissue fibers of the skin. Trauma and the ravages of disease produce damage in scar tissue more readily and the lesions are more difficult to heal than in normal skin.

Langer<sup>26</sup> plotted the lines of skin tension on the human cadaver by making holes in the skin with a round awl and noting the direction of elongation of these holes (Fig 718). Scars which are linear and lie in the proper direction of skin tension tend to

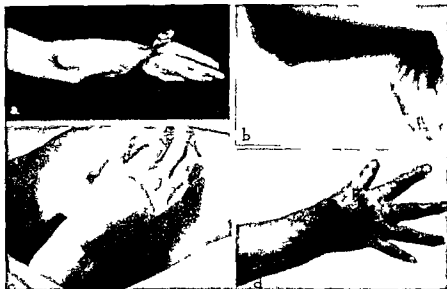


Fig 13—*a* Contracture of forearm in adult following burn in infancy. *b* perextension of the hand on the forearm so that the distal end of the fifth metacarpal lies over the ulna. The contracture caused lack of development of the ulna and subluxated the radius at the radiohumeral joint. *b* x-ray of the forearm and hand to show distortion from contracture. *c* pedicle flap obtained from the abdomen after excision of the scar tissue to the wrist and hand after lengthening the extensor tendons and tendon of the flexor carpi ulnaris and after excising 4 cm of the radius. *d* the hand in extension after division and revision of the pedicle flap.

ease or by intention as in operations. Should there be a combination of trauma and disease the resultant deformity will be greater. The amount of scar deformity depends on its extent and depth and also on its location. A scar over an exposed part is more disfiguring than such a deformity which is covered by clothing and different areas affected to the same extent may show varying degrees of deformity because of their position. With similar lesions the eyes and lips may thus be more distorted than the cheek or neck.

Scars are composed largely of connective tissue with a thin epithelial covering. Usually the sebaceous and sweat glands are ab-

spread but little whereas those scars which lie in a different direction to these tension lines of Langer often spread unless the skin tension is completely overcome by careful suturing of the tissues in the depths. Operative incisions should be made if possible in the proper lines of skin tension. Whenever possible the wrinkle lines should be followed. It will frequently be found that an incision through the skin can be made in one direction and after the skin edges have been retracted important structures can be approached through an incision in another direction. Judicious selection of these directions will result in a lessened deformity.

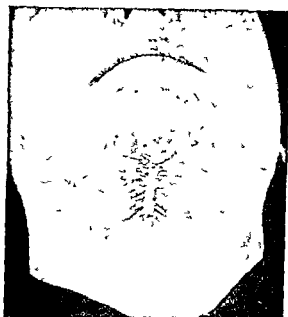


Fig 714—Scar in the submental region from an ill advised median incision made to reduce a double chin. Note the spreading of the scar. Transverse incisions in this region are preferable.



Fig 715—*a* and *b* Pulsating scar following drainage of brain abscess through a trephine opening. After excision of the scar, a square area was countersunk in the bone around the trephine opening. Two rib grafts were used, one on each side, and held by a third "keystone" rib graft wired at each end, *c* and *d*, after treatment.

Where lacerations occur with displacement of tissue, care should be taken to replace the parts in their original positions as well as possible. Later adjustments may be made if healing has already taken place with the parts in malposition.

Larger depressions may demand undermining and filling out of the spaces with fat, cartilage or bone grafts. Other more extensive depressions can best be corrected by the transplantation of pedicle flaps, which may contain not only the skin and subcu-



Fig 716—*a*, Scar following crucial incision for a carbuncle of the back of the neck. Note the width of the scar in the median line and the narrowness of the transverse scar. The optimum incision in this region is approximately transverse, *b*, result after partial excision of two opposing flaps and advancement of two other flaps.

Depressed linear scars in soft tissue may sometimes be corrected by local plastic operations without the transfer of tissue from a distance. Incisions about these scars through the depressed skin and subcutaneous tissue should be made at right angles to the inverted skin surface so that when brought

taneous tissues but fascia, muscles and even bone. With loss of substance, replacement should generally be made with tissue which resembles the destroyed tissue as much as possible.

Small fistulas from the exterior to cavities lined with epithelium, as in the nose or

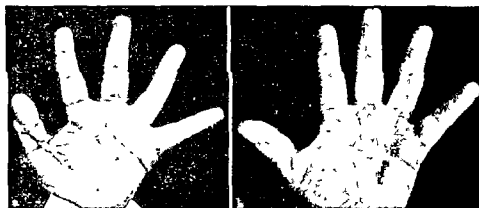


Fig 717—*a*, Scar of palm and thumb producing limitation of motion due to contraction, *b*, release of contracting scar by double Z incisions.

together the cut edges can be approximated throughout their extent. The upper layers of the scar tissue may often be excised, leaving the remainder as a foundation on which the undercut tissue on either side can be placed by drawing the subcutaneous tissue together with a buried line of sutures.

mouth, require an epithelial covering on the inner as well as on the outer surface; otherwise the area will heal by scar tissue and cause contraction. If the fistula is small, the epithelium around its orifice may be undermined and reflected to cover the inner opening. Undercutting of the surrounding exterior

tissues may then allow simple closure to be made. If the denuded area caused by turning in epithelium-covered flap is too large to permit this a pedicle flap can be used to close the external defect. Should the size of the fistula be so great as not to allow this type of closure a pedicle flap previously

be stimulated until a satisfactory bed is obtained. Excessive granulations should be reduced by the application of a silver nitrate stick or by excision. While the area is being made suitable for grafting contraction of the parts should be overcome by maintaining them in hyperflexion or hyperextension

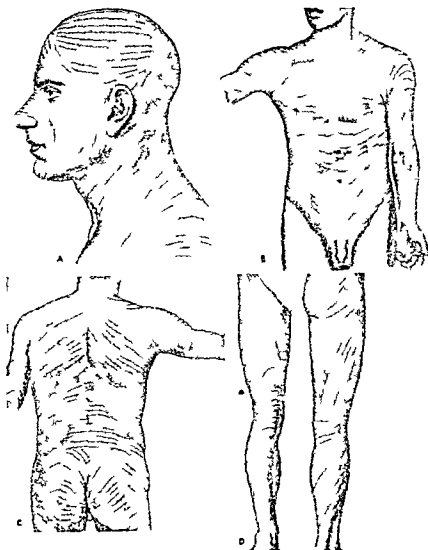


FIG. 19.—Showing the lines of normal tension of the skin known as the lines of Langer. Incisions through the skin across these lines will gape wider than those cut parallel to the lines and incisions closed parallel to these lines will be less likely to encourage scars than those closed across the lines. The elasticity of the connective tissue throws the papillary layer into definite folds which cause these patterns. The epidermis plays no part in the formation of these folds, as it merely covers the corium beneath. These patterns are practically uniform with only minor individual variations.

made with skin on both sides may be used. This flap may be formed either by reflecting the end of a skin flap on itself or by transplanting a full thickness graft to the under surface of a flap (Fig. 708).

When extensive injury has caused wide destruction of skin granulation tissue should

to prevent subsequent limitation of motion by contraction. Grafts should be applied at the earliest possible moment. This early grafting hastens recovery and lessens the growth of dense immobile scar tissue. If free skin grafts are to be applied thick split



skin grafts will heal more rapidly and give a better appearance than small deep grafts. Pedicle flaps may be used subsequently if required.

As scar tissue limits development in growing children, its early removal will tend to allow normal development of the affected part.

After epithelization of a wound has occurred, the underlying scar tissue continues to contract. This may sometimes be helpful, but occasionally the contraction may distort surrounding tissues and cause loss of function by limiting motion. This functional loss oc-

By this means the scar is lengthened, and with longitudinal pull on it, an accordion-plaited effect will take place.

Transverse incisions through broad scar contractures, with judicious lateral undermining, may relieve the tension of the contractures. The denuded areas can be covered by thick-split skin grafts, by whole-thickness skin grafts or by pedicle flaps. Flaps tend to contract less than free grafts.

Hypertrophic scars and keloids are unsightly and are sometimes difficult to overcome. The hypertrophic scars are composed of small collagen fibrils, whereas the keloids

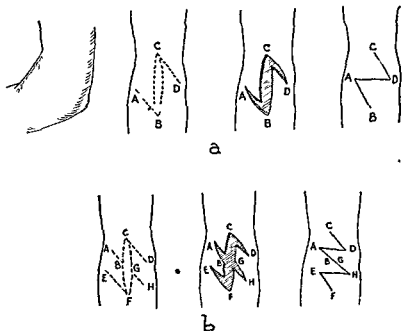


Fig. 710—*a* Single Z incision with transposition of flaps to overcome the "bow-string" effect of a linear scar at the elbow. The scar is excised and after an oblique incision is made at each end the flaps are transposed and sutured. The resulting scar is doubled in length, and on extension "an accordion-plaited" effect is produced. *b* the double Z incision with transposition of flaps is frequently found to be more advantageous than the single Z incision.

curs particularly when the contracture is in the neighborhood of joints especially over the flexor surfaces.

Scar tissue by its contraction may cause pain when nerves are affected and may even produce paralysis of nerves. Depending on its extent and depth, scar tissue may cause more or less loss of motion of the outer surfaces over the deep structures.

Longitudinal linear scars over flexor surfaces about joints may cause a bowstring effect by their contraction. Excision of the scar, with Z incisions and transposition of flaps, may overcome the bowstring effect<sup>28</sup>

have large collagen fibrils. The factors producing hypertrophic scars and keloids are not fully understood. Some persons have a greater tendency to produce them than others. Keloids, when excised, almost always tend to recur, with an increase in size, and excision is contraindicated unless appropriate measures are taken to prevent this return. Some surgeons reduce hypertrophic scars by the application of trichloroacetic acid, but this may increase the growth of keloids.

Both the hypertrophic scar and the keloid respond to irradiation and may be reduced

in elevation and softened by this means alone. The keloid is usually best treated by means of excision followed by irradiation which is given over a long period. Great care must be taken not to burn the patient. Several treatments with small dosage are safer than fewer treatments with heavy dosage. A satisfactory method is to cover all but the raised area with a lead shield and give a roentgen ray treatment with a dosage of 100 r once every two weeks for two months followed by a month's rest. Later courses of four treatments can be given if necessary. The earlier irradiation is given after excision the more effective will it be.

### TATTOO MARKS

A tattoo is an indelible mark made by puncturing the skin and introducing some pigment such as carbon into the punctures. If the pigment cannot be absorbed by the body it produces a lasting mark. Coal miners are unwittingly disfigured in this way. Gunpowder and dirt may also be embedded in the skin accidentally. The accepted meaning of the term tattoo mark however is a mark produced intentionally by a more or less expert person by introducing foreign bodies beneath the surface of the skin with needles usually in designs or patterns. Because of uncleanly methods used infection and syphilis may develop in the tattooed areas.

Many people especially seafaring men under the influence of alcohol allow themselves to be tattooed. They often regret the step when sober and subsequently wish the tattoo marks removed.

If the foreign bodies lie in the upper layers of the skin they can be removed by one of several methods. The skin containing the foreign bodies may be shaved off with a razor or large knife as in the removal of a thick split skin graft and if very superficial only slight scarring will result. The more deeply the skin is removed the more pronounced will be the scar. Another method is that of tattooing the mark with a 2.5 per cent solution of tannic acid and after protecting the surrounding skin with vaselin rubbing in a silver nitrate stick.<sup>22</sup> A thick eschar forms subsequently and may carry away the foreign bodies when it comes away. This method is unsatisfactory when

the deeper layers of the skin are involved and unfortunately in most cases the pigment is carried deeply into the skin. If the pigment is deeply embedded and the tattooed area is of small size it can be excised and the defect closed by undermining on both sides and approximating the skin edges and the subcutaneous tissue with two or three layers of sutures. Larger tattooed

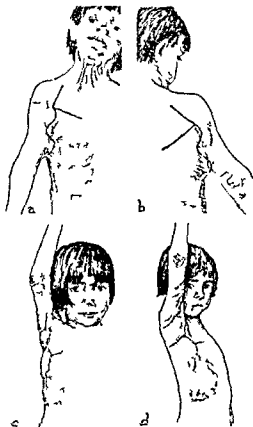


Fig. 20—Release of an arm and all skin on the mark. (a) tattoo of male. (b) tattoo of female. (c) tattoo of male. (d) tattoo of female. Before operation. (e) and (f) after operation.

areas may require entire excision and the covering of the defects with thick split skin grafts, full thickness grafts or thin flap grafts.

Foreign bodies such as powder granules and dirt accidentally introduced in wounds should be carefully and completely removed at the first treatment. If however the wounds have closed with these granules embedded the scars may be excised or if the granules are embedded only in the upper layers of the skin they may be shaved off in the same way that a thick split skin graft is removed.

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## REPAIR OF DEFECTS OF THE FACE.

## HANDS AND FEET

## THE FACE

Congenital clefts of the face result from persistence of embryonal fissures. The most important clinical defects are *cleft palate* which results from non union of the palatine processes and *cleft lip (harelip)* which results from non union of the maxillary and globular processes. It is well to remember that these regions are normally fused by the eleventh week of embryonal life, because

some of the most convincing maternal impressions may be given to account for the occurrence of a cleft lip or palate.

The actual cause of these clefts has not been definitely determined although many theories have been advanced. The most constant finding is that heredity apparently plays an important role and that multiple cases may occur in the same generation. This point is important as a guide to prognosis for parents who are interested in determining the chances of having a normal child if there are cases of cleft in either family or if the parents have already had one deformed child. However no definite percentages are available in this regard.

Figure 721 represents the various possible facial clefts in relation to the embryonic clefts. Many different degrees of each type can occur. Cleft lips are the most common but there can occur microstomia, lateral facial cleft that may extend clear through the eye socket very rarely, median cleft of the upper lip and perhaps most rarely median cleft of the lower lip.

Cleft lip and palate may occur in a great many forms ranging from a notch in the uvula or the lip to a wide open cleft of the lip, alveolus and palate (single or double). Attempts have been made to classify all types but the best record is a simple diagrammatic representation of each type of case.

**Repair of the Cleft Lip**—Early closure of the lip is important in that it allows the mother to exhibit her baby without apology; it helps control respiratory infection and feeding is made easier for both the mother and the baby. If a lip is closed soon after birth over an open alveolar cleft nothing being done to the bone the alveolar arches will be compressed into approximately normal position by the pressure of the lip within twelve months in most cases. Although the procedure is difficult in small infants the advantages to the baby and its mother outweigh the disadvantages to the surgeon.

The specific objectives of the operation should be to bring about the best possible immediate restoration of the lip, alveolus and floor of the nostril. If this is well accomplished subsequent growth should further improve the result by bringing the external nose to the midline and gradually closing the open alveolus.

Figure 722 illustrates the modification of the Mirault operation which the writers employ in nearly all cases.

Figure 723 illustrates the simplest type of operation for cleft lip and is the one recommended if the operation is undertaken with out experience.

Secondary operations are necessary in a large number of cases. If there has been no early correction of a hard lip or if the correction has not resulted in good nasal contour there will occur a deformity that becomes worse and more solidly fixed with the growth of the face. This deformity is perhaps worst when there has been an early forceful closure and wiring of the spread maxillae. The surgical correction necessitates an extensive procedure with complete freeing and rota-

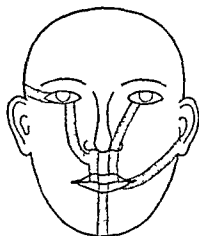


Fig. 721.—Diagram to represent the possibilities of facial clefts in relation to the embryonic clefts (Meckel).

tion of the nostrils into position. If there are not sufficient or properly placed teeth to maintain a normal profile of the soft parts a dental prosthesis may be necessary for additional support.

**Repair of the Cleft Palate**—Repair of a cleft palate is performed by the writers before the second year but the time varies among other surgeons from the fourth month by those who use a direct bone wiring procedure up to the fifth year by those who do not think that final speech habits are influenced by this delay. Factors in favor of the late operation are a lower mortality and greater ease of operation. The Dieffenbach-Warren operation may be taken as a standard procedure (Pl. 725). In the procedure

of Veau, which has wide acceptance, the front part of the palate and the space between the alveoli are closed at the time of

defect of the palate requires wide mobilization of the tissue and accurate suturing to insure success



Fig 722—*a* and *b* Modified Mirault operation Point *A* is located across the base of the columella *B* is at the lower end of the philtrum and *C* is half way between *A* and *B* *A'* is at the junction of the inside and outside of the alveoli *AC* and *CB'* are the equal distances of *AC* and *CB* with *B'* on the vermillion border *BZ* and *BZ'* are incisions to permit interlapping of the vermillion border and thereby prevent notching *AC'* can be curved if there is very little tissue available *c* The dotted line shows the necessary undermining The suture is being passed to engage the muscle and establish the level of the floor of the nostril This procedure is somewhat difficult to carry out but there is minimum sacrifice of tissue and there is less apt to be a notching of the lip and general lack of tissue than with many other procedures



Fig 723—Husson Rose type of operation, perhaps the simplest method of repair



Fig 721—Complete double cleft of lip and palate with premaxilla and prolabium entirely out on the tip of the nose Correction shown after a one stage procedure removing all vermillion from the prolabium At a later date the columella can be advanced unless it develops spontaneously In these cases the premaxilla should never be excised

the lip operation and the soft palate later The closure under the lip and through the alveolus is done on the writers' service at the time of the closure of the palate or at a later date if necessary The repair of a small

Speech training for every patient with cleft palate is essential To produce normal speech, the nasopharynx must be closed off except for a few sounds that are normally directed through the nose This closure is

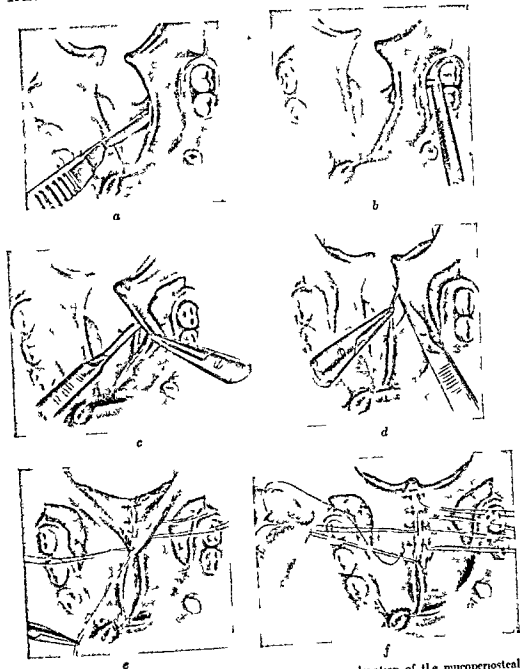


Fig 720—*a* Mobilization—Warren's approach *b* Mobilization—elevation of the mucoperiosteal flaps The point of the angle elevator enters the lateral incision just in front of the postpalatine foramen and then by working forward the mucoperiosteum and with it the palatine artery can be freed from the underlying bone as far forward as the incisive foramen *c* Mobilization—division of the palate aponeurosis *d* Denudation—of the cleft border by paring *e* Suturing—the uvula and upper surface of the velum *f* Suturing—the mucoperiosteal flaps The mucoperiosteal palate flaps are united with vertical mattress sutures bringing several millimeters of the raw upper surfaces into contact. It is at the junction of the velum with the mucoperiosteal flaps that one is most likely to have failure of union owing either to insufficient relaxation or a deficient blood supply, and it is to be remembered that tight suturing interferes with the blood supply (Blair and Brown Surg., Gynec. & Obst. 59:309, 1934). If there is any doubt of the integrity of the major palatine arteries it is safer to suture as far forward as the original relaxation will permit without tension and to do the remainder at a subsequent stage as failure of union is less catastrophic than a slough or a distorted flap.

naturally performed by a sphincter action of the levator palati, pharyngeal constrictor and palatopharyngeus muscles, therefore, the aim of the operation should be the pro-

duction of a long palate with a mobile soft part. Unfortunately in many results obtained after repair of the palate the pharynx is far from closed and speech is still

hindered by the leakage of air into the nose. It is a great advantage to place the patient under the direction of a speech trainer but if this is not possible the mother can learn the essentials and then train the patient at regular intervals.

**Elongation of the Palate**—In an effort to afford better nasopharyngeal closure during speaking several operators have described methods for elongating the palate. Dorrance's procedure which he calls the push back operation is best known. It consists of making a delayed flap of the entire front part of the palate with sacrifice of the major palatine arteries at the first stage. In a second operation the whole palate is raised

Some surgeons have carried out the procedure in cases of complete cleft and have left a hole anteriorly that has had to be closed with a dental obturator. In suitable cases of complete cleft the elongation can be carried out after the cleft has been closed by splitting the palate in two care being taken to leave the nasal mucosa intact and then setting the palate back without leaving an opening anteriorly.

Pharyngoplasty has been advocated mainly by Wardhill to constrict the nasopharyngeal opening by making a transverse opening on the posterior pharyngeal wall and then reefing toward the midline the mucosa and superior constrictor muscle.

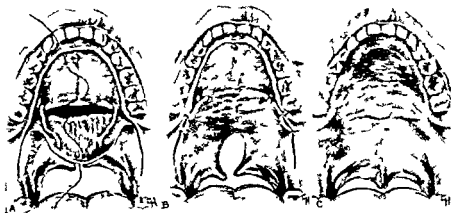


Fig. 726—A The whole palate has been loosened from the bony palate, the nasal mucosa opened, the major palatine arteries preserved and the suturing started to carry the palate back. B The palate is held back with three to five sutures and the exposed bone in front is allowed to cover over. Healing is usually complete in one month. C The elongated palate is shown with the posterior opened space much smaller than it was originally. (Brown)

again pushed back toward the posterior pharyngeal wall and anchored there and the cleft is closed. This procedure is used also when the palate is not cleft but so short that cleft palate speech results. Dorrance calls this condition congenital insufficiency of the palate.

Another method of elongation is shown in figure 726 in which a direct flap is taken with the major palatine arteries preserved and the whole palate moved backward at the first operation. When possible the cleft is closed at the same time so that only one operative procedure is necessary.

These elongation operations are mainly applicable in cases of partial cleft in which the bony palate will be left in front to preserve separation of the nose and mouth.

**Reconstruction of the Lips**—The blood supply through the coronary vessels makes it possible to switch vermilion bordered flaps from one lip to another in order to improve the proportional amounts after removal or loss of skin from one lip. If the defect is near the angle a triangular piece can be swung directly into place preserving the coronary vessels in a mucous flap. In such cases the pedicle of the flap will form the new angle of the mouth. The donor lip defect is closed by pulling the lip over to the cheek with the making of any further adjustment necessary to lessen the distortion about the nose and upper part of the lip. The corner of the mouth is put in the best obtainable position but this may be improved if necessary by subsequent opera-

tion The suturing should insure contact for the full depth of the wound (Fig 707 a) If the defect is near the middle of the lower lip the remaining lateral portion may be raised as a somewhat rectangular flap and

obtained by bringing in a flap of suitable size from the scalp forehead or chest Figure 729 illustrates the use of a scalp flap in a man in a woman a flap from the forehead is used

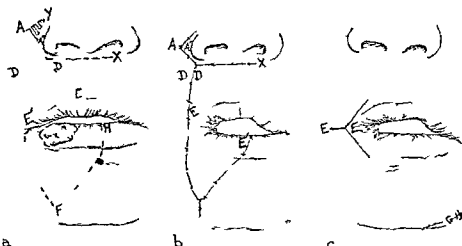


Fig 707—The lower triangle is excised and the one from the upper lip is swung directly across. The adjustment under and at the side of the nose is to improve nasal balance as this is a large red flap. The adjustment on the nose is made and the final healed result to the lip opening.

swung across to fill in the center. The defect at the side of the lip can then be filled in with a flap from the upper lip (Figs 707 b and 728). When a flap is swung directly from one lip to the center of the other the pedicle must of course extend across the mouth and remain there until the flap has established its new blood supply. It is usu-

**Reconstruction of the Nose**—The nose is the most conspicuous feature of the face and any exaggeration of size or deformity makes it a target for undesired attention and is likely to produce a deprecatory or disquieting self-consciousness. The general plan of correction for a nasal defect should always be worked out before the decision to



Fig 728—Patient on whom plan shown in figure 72 was used after a lateral rectangular flap had been selected over the center.

ally cut in two or three weeks. For complete reconstruction these flaps may be used in combination with others of the full thickness of the cheek, which are advanced along the jaw, or flaps from the face alongside the nose with the base down may be put entirely across the defect. The most satisfactory result for a full restoration is usually

obtained by making the use of a model of the face usually being of great benefit.

**Saddle Nose**—A depression of the bridge of the nose may occur as a result of injury, the formation of a septal abscess, resection of the septum and destruction of the septum (and mucous lining) due to syphilis. For building up the defects the transplants



tion of autogenous fresh cartilage is usually employed although fresh homografts and preserved homografts may prove successful

**Hump Nose**—An unsightly nose is a family or racial characteristic often constitutes sufficient worry to the patient to war-

shortening of the septum to reduce the length of the nose. After removal of the bony hump it is necessary to reduce the width of the upper part of the nose by moving in the nasal bones. In proper hands the operation results in marked improve-



Fig. 29—*a* Complete loss of the lower lip and chin from paste treatment for cancer. *b* Restoration with the pedicle scalp flap. The lining was obtained by turning in the scar and epithelium. *c* Final result: a watertight mouth. The defect of the scalp was covered with a single large split graft. If desired a vermilion border can be obtained by turning a mucous flap from the inside of the upper lip.

rant correction. The correction in each case must be planned according to the deformity of the nose and the balance of the patient's features. In almost every instance all struc-

ture is in appearance and is usually very satisfactory.

#### *Deformities Resulting from Fractures*—

It is possible that in most cases an apparently unexplained severe nasal deformity is the result of an untreated fracture sustained early in childhood. The mechanism is probably a crushing in of the nasal bones and frontal processes with impingement on and perhaps fracture of the cartilaginous septum. If not corrected this deformity frequently becomes worse with marked distortion of the septum and deviation of the nasal bones.

**Total Reconstruction of the Nose**—The main causes of total loss or destruction of the nose in the writers' series have been cancer and its treatment, syphilis, tuberculosis, automobile injuries, bites from animals, and human fights, paraffinomas, burns, and excessive irradiation. There has been one undiagnosed case of necrosis and one case of necrosis several years after an implantation (by another surgeon) of some metal for a depressed bridge.

The diagnosis in this group should involve a study of the surrounding field to determine, for example, whether or not any further disease or new growth persists. If the destruction has been due to a basal cell carcinoma, extreme care should be taken and



Fig. 730—Restoration of a saddle nose with a pedicle flap from the arm for lining and costal cartilage for support.

tures of the external nose are reduced in size or changed in shape. Such a correction involves removal of the bony and cartilaginous hump, shortening of the upper lateral cartilages, reduction in size or change in shape of the lower lateral cartilages, and

if necessary, further treatment or destruction employed. In this region, basal cell growths are notoriously apt to return. This is also a field for the occurrence of mixed types of growths, the basal-squamous carcinomas. If the surgeon during a repair operation finds evidence of a recurrence deep in around the pyriform fossae or down along the wall of the nose, the work must either be delayed or abandoned entirely and further steps taken for the control of the growth.

The plan of repair is always, if possible, to use a delayed flap taken from the forehead and to use skin surrounding the defect as the lining of the nose by turning in small delayed flaps. Flaps from the neck, chest and arm are used only if necessary.



Fig. 731—*a* Complete burn of the front of the neck with open bite of the lower jaw due to the pull of scar tissue. *b* method of dressing free skin grafts. This was the first postoperative dressing; the outside heavy gauze fixation has been removed and the sea sponges used for pressure are seen forming a cast of the area. *c* full restoration of the skin from the chin to the sternal notch; complete function and spontaneous correction of the open bite after release of the pull of the scar. The deformity was completely released first with thick-split grafts and later, to effect better smoothness, a full thickness graft was put in entirely across the neck.

Congenital deformities occur in great variety—blockage of one or both nostrils, half nose, double nose, split nostrils, total absence of a nose and the deformities attendant on ocular hypertelorism.

**The Repair of Deformities of the Face.**  
—The multiplicity of deformities about the face and the rather complicated procedures of repair prevent any very complete discussion of each type in the present text. The principles of repair, however, are not difficult and may be considered briefly. A diagnosis must be made of the condition just as for any other surgical lesion. There is necessity for a careful study of the deformed or missing area in order to determine its extent accurately. Next, the possibilities of repair must be painstakingly considered, for ex-

ample, whether a pedicle flap or a free skin graft will suffice, and whether transplants of bone, cartilage or fascia may be necessary. This phase must be accurately fitted in with the availability of tissue for making the repair and further with the general physical condition of the patient for standing long operative procedures.

Burns of the face and neck can be repaired in most instances with free, full thickness or thick split skin grafts, but pedicle flaps are used by many operators (Fig. 731).

**Types of Free Grafts.**—The *Ollier-Thiersch graft* is very thin and includes the epidermis and nearly always some of the derma. The statement found in most texts that the Thiersch graft is cut above the

papillary layer is not correct; a graft of this thinness would be practically useless.

The *full-thickness graft* (Wolff-Krause) includes the full thickness of the skin down to the subcutaneous tissue. It can be cut accurately to pattern and, if successful, gives the best repair of any type of free graft. It must be applied without any attached fat and requires careful postoperative attention.

Between the thickness of the Ollier-Thiersch and the full-thickness graft, one may be obtained that possesses nearly all the ease of application of the Ollier-Thiersch graft and many of the virtues found in the full-thickness graft. This graft may be from one third to three fourths the thickness of the skin and might be called a thick Ollier-

Thiersch graft. To distinguish it from the true thin Thiersch graft, however, the writers have called it a *thick-split graft*. It can be cut rapidly in large pieces, and the area from which it is taken heals promptly

*Calibrated Grafts*—Recently the Padgett dermatome has become popular. This instrument enables a relatively inexperienced surgeon to cut a split-thickness graft of fairly uniform nature and thickness. It is

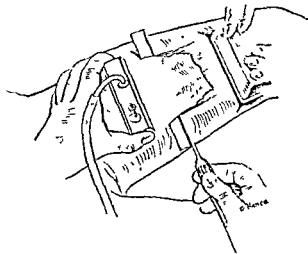


Fig 732—Method of cutting a thick-split skin graft The main essential is a long very sharp knife, the skin is lightly greased, an assistant holds firm traction on one end and the operator slides his traction along ahead of the knife Here a suction retractor is being used which is a vacuum box attached to a suction machine

without distortion The thickness and cutting of this graft are shown in figures 732 and 733

Deep defects of the face, especially those involving the full thickness of the cheek or

also valuable for removing such grafts from donor sites unsuited to free-hand cutting, namely, chest wall, abdomen and back. The principles involved in getting a successful "take" or result from the graft so obtained

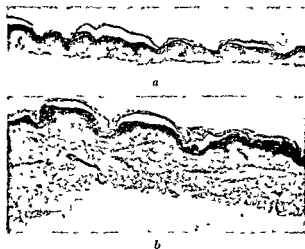


Fig 733—*a* Thickness of the usual Ollier Thiersch graft It contains a small amount of derma and is not cut through the papillae, *b*, a thick-split graft, in this instance, about two thirds of the full thickness of the skin \*

those extending deep in the orbit, require pedicle flaps for adequate repair, and in the case of full-thickness loss of the cheek, the repair must of course be lined both inside and out.

are not altered The Caltagirone knife has been constructed for the same purpose.

*Deformities of the Jaws*.—An open-bite deformity may result from the pull of scar

\* Surg., Gynec. & Obst., 50

tissue in the neck and if this is simply released the occlusion of the teeth may be spontaneously corrected (Fig 731)

In ankylosis of the temporomandibular joint the jaw is pulled to the ankylosed side and flatness results on the opposite side. After correction of the ankylosis by resection the deviation remains and the facial contour may be greatly improved by implanting a piece of costal cartilage along the outside of the jaw on the flat side.

Loss of substance of the jaw allows collapse of the remaining fragments toward the midline. For restoration there must be complete healing, adequate soft tissues available

and placing the free end of the cartilage high up in the region of the glenoid.

Retraction of the lower jaw can be somewhat corrected by osteotomy of the ramus with a shifting forward of the lower on the upper fragment and maintenance of firm fixation until union occurs. The profile can be further improved by implantation of cartilage over the chin.

*Prognathism* or excessive prominence of the lower jaw is corrected by removing a full thickness section from each side of the jaw and maintaining the fragments firmly until there is solid union. In the upper jaw it may be necessary to extract teeth, remove



Fig 734—*a* Facial paralysis of the temporalis anterior muscle. The lower lid of the right eye is paralyzed and has been supported with a toggle strip of fascia lata. There is still to be noted an expression of an expressionless face parallel to one side by the globe can be easily seen and tearing of the eyes of fascia lata. There is still to be noted an expression

to receive a bone graft, adequate separation and preparation of the remaining fragments and adequate fixation of the jaw usually by means of dental splints. For restoration of the chin and body the writers have used the angle of the scapula, but this is not recommended, a free graft of bone from the rib, humerus or tibia being preferable. Occasionally for small defects a pedicle graft of a section of one of the fragments with the platysma muscle left attached will suffice (Cole).

For complete loss on one side a section of the seventh rib with its attached cartilage can be used, the bone being fastened to the fragment in front, letting the costochondral junction suffice for the angle of the jaw

the prominent alveolus and substitute a dental prosthesis.

*Facial paralysis* which is not amenable to nerve suture or anastomosis can be greatly improved by implantation of strips of fascia lata which traverse the cheek from the temporal or parotid fascia to both lip, the angle of the mouth and frequently around the lower orbital border and are then looped back to the fascia and fastened with enough tension to correct the distortion due to the pull on muscles from the opposite side. A method of fixation of fascial strips into the temporal muscle which is innervated by the fifth nerve has been successful even to the point of producing some emotional expression.

**Defects of the Scalp.**—Defects of the scalp can nearly always be repaired with free grafts, either thick split or full thickness. Free grafts will not grow on bare bone, even where there is fresh denudation of periosteum, and if it is recognized that the periosteum is stripped up, grafting should be delayed until granulations or scar epithelium covers this area. If there has been a wide burn with loss of hair, it is best to resurface the area early, because scar epithelial healing may never prove satisfactory.

Late distortion of the scalp, forehead, eyebrows and lids may be corrected by re-

thick-split grafts. It will be found that the scalp will not shift unless taken up from the periosteum, and as free grafts will not grow on bare bone, it is important not to strip up periosteum accidentally when raising the flap (Fig. 735).

**Avulsion of the Scalp.**—This not uncommon injury results when the hair is caught in moving machinery. If the periosteum of the skull has been removed, then one must wait for granulations to develop before applying a skin graft. If the periosteum is intact, the area may be covered with a skin graft immediately or later on the granulat-



Fig. 735.—*a*, Deformity following osteomyelitis occurring after an operation on the frontal sinus. Both plates of the skull are missing over the area of thin scar in the center. *b*, repair was effected by shifting large scalp flaps to obtain a normal eyebrow level and to cover the dura with full thickness scalp instead of the thin scar. Skin graft repair was necessary over the vertex, where the flaps were obtained. In shifting large scalp flaps, serious hemorrhage may occur, and the procedure should be executed with the greatest care.

lease of the contracture, replacement of the tissues, especially the eyebrows, in their normal position and filling in the resultant defect with a full-thickness or thick-split skin graft.

Wide loss of scalp tissue resulting from the use of flaps for repairs of the face from the removal of moles and other growths may all be restored with thick-split grafts.

Bony defects are usually associated with loss of scalp tissue, and many unsightly deformities can be improved by the shifting of tissue to fill up an uneven contour and by replacement of any open areas with

ing wound. In no case has the replacement of the avulsed scalp as a free transplant been successful to the point of having the healed defect covered with hair. One instance is known in which the avulsed tissue was thinned until it resembled a split-thickness skin graft and was then replaced; a partial "take" occurred, but there was no growth of hair.

**Reconstructive Surgery of the Orbital Region.**—The satisfactory surgical correction of defects about the orbit may necessitate some of the most complex and trying procedures. The complicated anatomy

and physiology and the wide variety of lesions—congenital and acquired—make careful planning and execution of the details of reconstruction imperative; only the common types can be included here.

**Ptosis.**—In the congenital type of ptosis there is lack of action of the levator palpebrae muscles, so that the pupil is covered by the lid most of the time. The patient may not use the eye at all, but he can attain

gliomas, neurofibromas, mixed tumors and dermoid cysts

**Epicanthus** is due to vertical shortness of the tissues inside the inner canthus. There is an apparent redundancy of tissue in the transverse direction, but in the surgical correction, too much tissue is never found. The usual type is congenital and may be accompanied by ptosis, another congenital variety accompanies total or partial absence



Fig 736—Congenital ptosis corrected with a fascial loop fastening the tarsal plate to the frontalis muscle

some elevation by arching the eyebrow with the frontalis muscles. He can also hold the head back so that the pupils may be directed downward, or a child may even use his finger to elevate the lid out of the line of vision. Various plans have been proposed for elevating the lid, but perhaps the most satisfactory is the use of a fresh autogenous strip of fascia lata looped through from the frontalis to the tarsal plate to connect the

of the nose. Traumatic epicanthus may result from a depressed fracture of the nasal bridge. This type may be relieved by building up the nasal bridge, but if there has been loss of tissue, frequently there must be replacement by either a free graft or a flap.

The correction of the congenital type usually depends on a careful flap operation in which one or two flaps are taken from the transverse fullness and switched so as to



Fig 737—Epicanthus corrected by a local flap operation of splitting the web in two and reversing the two surfaces, making them transverse instead of vertical

paralyzed lid directly with the active forehead muscle. If there is thought to be enough levator action to raise the lid, the simplest procedure is to shorten this muscle.

Ptosis may also occur from trauma, and the correction may be extremely difficult if there is scar fixation of the lids or contraction of the socket following loss of the globe. A tumor may encroach on the lid so that elevation is impossible; the most frequent types of these are hemangiomas, lymphan-

replenish the vertical shortening. It has been claimed by others that correction of the natural epicanthus of Chinese has been satisfactorily accomplished by plication and removal of a crescent of tissue over the bridge of the nose.

Depression of the orbit from fracture, with or without the loss of the globe, forms a difficult type of facial lesion to correct if displacement is great and fixation has become firm.

A heavy blow on the orbital border usually drives the zygoma down and back and usually at least three fractures result—at the zygomatic maxillary suture line at the zygomatic frontal suture line and at the suture line between the zygoma and the zygomatic process of the temporal bone. The fracture may even extend down around the walls of the antrum with marked comminution.

When the orbital floor is depressed the globe of course follows it and diplopia may result. This is the most important physiologic derangement that occurs in these injuries and an effort should always be made to correct it. In a fresh injury the orbital floor and border are carried back into place by introducing a sound into the antrum

result from exophthalmic (or other pathologic) destruction or from trauma. The deformity causes eversion of the lid and exposure of the globe that cannot be overcome entirely even by forced muscular action. The main object of correction is the replacement of tissue so that the lid conjunctiva may settle back down on the globe and provide normal protection for it. This is carried out by complete relaxation of the scar so that the tarsal border freely covers the globe and then by covering the defect with tissue of suitable size and thickness. The material used in order of frequency are (1) free thick split grafts applied over wax forms, (2) free full thickness grafts, (3) pedicle flaps from the forehead and (4) double pedicle flaps from the skin of the opposite



Fig. 38.—Ears set back in one operation by elliptical excision on skin and cartilage from the posterior surface.

through the buccal fornix and forcefully elevating the border. An iodoform pick is then introduced carefully to act as a splint and is left in place for two weeks. If there is a normal antral opening into the nose the fistula into the antrum will close spontaneously. If fixation is allowed to occur with marked depression the sight of the eye may be useless (except for monocular vision) because of derangement of the extrinsic ocular muscles. Along with this trouble there is marked facial deformity that demands correction. If the vision or the globe has been lost the correction is entirely one of restoration of the contour and the correct height of the orbital floor for the prosthesis.

Loss of the surface skin of the lids (ectropion) usually results from burns but may

result from exophthalmic (or other pathologic) destruction or from trauma. The deformity causes eversion of the lid and exposure of the globe that cannot be overcome entirely even by forced muscular action.

The main object of correction is the replacement of tissue so that the lid conjunctiva may settle back down on the globe and provide normal protection for it. This is carried out by complete relaxation of the scar so that the tarsal border freely covers the globe and then by covering the defect with tissue of suitable size and thickness.

The material used in order of frequency are (1) free thick split grafts applied over wax forms, (2) free full thickness grafts, (3) pedicle flaps from the forehead and (4) double pedicle flaps from the skin of the opposite lid (the writers do not use full thickness flaps from eyelids). Eyebrows are practically always replaced with free full thickness grafts from the scalp. Only infrequent attempts are made to replace eyelashes.

**Deformities of the Ears.**—Congenital absence of an ear associated with failure of the development of the whole side of the face and jaw is the worst deformity of this region. There may be no external ear canal and it is perhaps best not to investigate the region surgically for fear of damage to the seventh nerve. The external restoration of an ear absent from this or any other cause is a tedious procedure and the final result at best is only an outline. However in men the absence of an ear is such a noticeable

deformity that and is usually sought. The repair is accomplished with flaps from the local region and the neck and with costal cartilage.

The most common deformity of ears is excessive prominence and here again especially in boys and men the correction may be very important more so if it exists only on one side. The operation consists of an

#### REPAIR OF SURFACE DEFORMITIES OF THE HANDS AND FEET

Burns are responsible for a large and very important group of deformities of the hands. As soon as they are seen every effort should be put forth to prevent the deep infection that will so rapidly fix tendons and joints and produce deformities that may never be overcome. For deep losses the first treat-

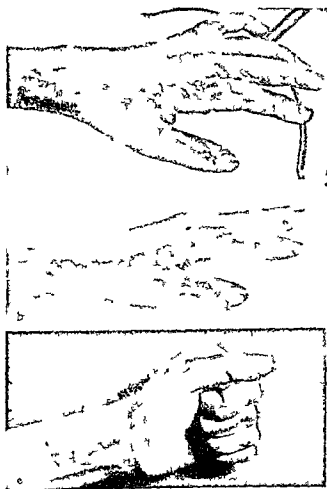


Fig. 39.—a A burn of the hand caused by a mangle about twelve days after the accident. b After two days of saline soaks, saline jelly, dressing and gentle debridement. c Final result from application of a single thick-skin graft. The patient was able to work after five weeks.

elliptical excision of skin and cartilage from the posterior surface.

An annoying deformity is the persistence of an open wound and hole following a mastoid operation. The correction can be made if there is complete healing by filling the defect with a flap of scalp taken from the occipital region after the hair-bearing skin has been removed and then covering it with a hairless skin flap from behind the ear along the edge of the wound.

ment should be active surgical drainage. Active movement should be encouraged; the fingers should be dressed separately and the whole hand kept in the position of function. The average burned area should be ready for grafting in three weeks if tendons have not been exposed and frequently the single application of a split graft may be all that is necessary. If there has been an extensive deep burn as soon as sloughed tendons have separated and the granulations are clean it



is often advisable to "dress" the wound with a thick-split graft, so that healing may stimulate activity and joint fixation may be limited, then later any necessary thicker repair can be undertaken (Fig. 739).

notably advocated by Kanavel, Koch and Mason.

**X-ray Burns.**—Radiation burns are found most frequently in doctors and respond best to wide excision through the full

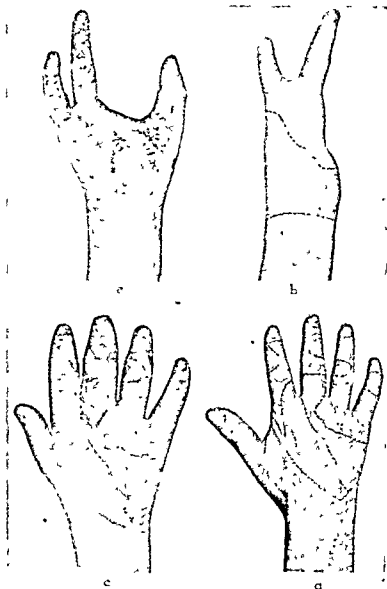


Fig. 740—*a*, Extremely bad x ray burn of the hand of a physician. The second and third fingers have already been removed because of carcinoma and active growth is now present. *b*, result of partial amputation removal of all skin of the dorsum of the fourth and fifth fingers and application of a thigh flap. The outflung graft higher on the dorsum is a one year old thick split graft put in later; *c*, ten day old split grafts on the opposite hand of the same patient, *d*, same hand as shown in *c* after one year.

The rehabilitation of the patient's activities should be started early, even before surgical restoration is started, if possible. Children usually take care of their own problems, but guidance in physical and occupational therapy is always beneficial. The use of splints may be required, as

thickness of the skin and repair with thick-split grafts. This procedure eliminates not only the individual keratosis but also the intermediary damaged skin. Small, isolated keratotic spots are removed with the actual cautery or electric current, and spontaneous healing is awaited.

Carcinomatous changes in the irradiated tissues may further complicate the problem. The simple superficial epitheliomas will not, as a rule, require excision deeper than the subcutaneous fascia, and the resultant defect can be immediately repaired. In dealing with these, it is usually best to include in the excision the whole area of damaged skin and immediately replace it with a pocket flap

can be carried out on the toes, but it is usually not necessary to do so.

**Constricting Bands.**—Constricting bands occur from small constrictions of the tip of a finger or toe up to very heavy complete circular indentations at the wrist or ankle or above. The cause is often said to be embryonic bands, and also it is thought that these may cause intrauterine amputations,

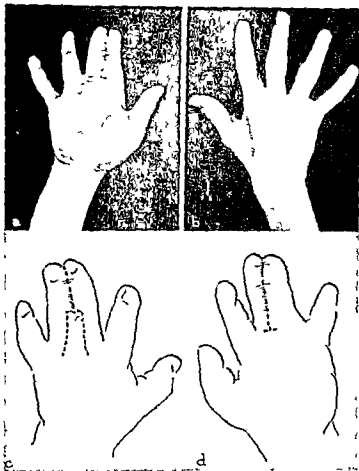


Fig 741—*a*, Congenital web fingers, *b* correction obtained by turning a square U shaped flap from the dorsum between the fingers into the proper level on the palmar surface and grafting the defects resulting from separating the fingers, *c* and *d*, diagram of the flaps used. An inverted T is opened on the palmar side and an inverted square U on the dorsal side; the fingers are then entirely separated and the defects covered with thick-split skin grafts. Both sides of one finger are never operated on at one time, as recommended by Kanavel, because of the chance of necrosis from loss of both arteries.

with a free skin graft, rather than, as has been the more common custom, make a number of small local excisions (Fig 740).

**Web Fingers.**—Web fingers are perhaps the most frequent congenital deformity for which correction is sought. No actual cause is known, but it is thought that if the correction is accomplished fairly early in life, the hand has the best chance to develop (Fig 741). The same operative procedure

but this theory has not had a final solution. The repair of these defects is usually accomplished by careful dissection of one half to three fourths of the complete circumference and then closing the flaps together by making appropriate incisions into them that will allow two or more small flaps to be brought across from one edge into the other.

Deformity or loss of the pad of a finger tip usually results from the placing of an

incision through the pad when a felon is drained and may be so painful or annoying that restoration is required. If skin surface is needed also a pedicle flap can be taken from the thenar or hypothenar areas if the skin covering is satisfactory. Koch has reported good results in free fat transplantation. Deformity of the eponychium also usually results from linear incisions employed in draining a paronychia. The cor-

ond and third metacarpals to change the action of the second finger into that of the thumb.

**Dupuytren's Contracture**—Dupuytren's contracture is an idiopathic disease of the palmar fascia in which shortening occurs beginning almost always on the ulnar side of the hand with resultant flexion deformity of the fingers. The involvement may extend up the fingers and over the whole palm.

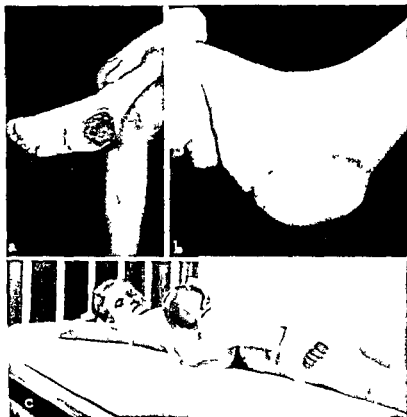


Fig. 42.—a. Avulsion of the heel with osteomyelitis of the calcaneus. The area is first cleared, freed of any loose bone fragments and covered with clean granulations. Then a direct pedicle flap is put in place from the opposite thigh. b. Following the flap healed all around the heel. The patient is now able to walk. These forearm flaps retain their original histologic characteristics and must be protected with a rubber sponge pad in the shoe. c. A direct pedicle flap is left in place for three or four weeks. After the flap is set loose the defect on the thigh is covered with thick split grafts.

rection of these is not very satisfactory and care must be taken not to make the deformity worse.

**Reconstruction of Fingers**—Reconstruction of a finger has been accomplished by transferring a toe, but no very normal looking results have ever been illustrated. A thumb has been built that has proved to be helpful in work by transferring a pedicle flap and putting a free bone graft into it and also by splitting down between the sec-

ond and third metacarpals to change the action of the second finger into that of the thumb. and cause the overlying skin to become nodular and attached. Joints may become secondarily deranged. Of many theories of its cause probably the only one of important association is heredity. There is usually no pain but slowly progressive crippling of the hand. The diagnosis is usually simple but mistakes have been made in diagnosing the condition as a contracture of the tendons. Treatment is complete removal of the palmar fascia and if necessary its prolonga-

tion onto the fingers and the application of full thickness skin grafts if closure cannot be easily obtained with the available skin. Extreme care must be taken to prevent injury to the nerves and vessels of the fingers. The papers of Kanavel, Koch and Mason may be taken as standard references.

#### Restoration of the Skin of the Foot —

Restoration of the skin of the foot may often be performed successfully with free skin grafts and in old deformities where there has been loss of skin it may be a necessary procedure as a preliminary to a bony operation. In other instances the sequence of repair may be reversed.

For the restoration of the plantar surface a free skin graft will not suffice over the main bearing points and it is necessary to

apply a pedicle flap—usually from the opposite thigh. This gives an amount of fat that is practically indispensable but even with this flap in place it is necessary to protect the area carefully with a soft sponge rubber pad. This is due to the fact that tissue transplanted from one area to another does not take on the characteristics of the new area. The sole of the foot is different at birth from the tissue of the thigh and even after the passage of years a thigh flap on the foot will still have the consistency of normal thigh tissue. Transplants in other parts of the body do preserve their original histological characteristics.

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## XXXVII ROENTGENOLOGY

### DIAGNOSTIC AND THERAPEUTIC ROENTGENOLOGY IN SURGERY

The employment of the x ray as a diagnostic means has become an essential part of the examination of a large proportion of surgical lesions. Few surgical interventions are now elected except in emergencies without first undertaking some form of roentgenologic study of the patient.

**General Considerations**—The roentgen images are only shadowgraphs recording the varying opacities through which the x rays pass, and they are subject to the possibility of numerous incorrect interpretations because of the fact that they are shadows. For successful interpretation it is necessary to become familiar with the roentgenologic aspects of normal structures to understand the technique of roentgenographic and fluoroscopic study, to refrain from making a diagnosis until everything possible in the way of roentgen study has been accomplished to avoid expressing any opinion from films which are not satisfactory and to recognize the limitations as well as the possibilities of roentgenographic investigations.

#### ROENTGEN FINDINGS IN BONE PATHOLOGY

Fracture lines are characterized by sharply cut margins usually with an irregular course which particularly in the skull does not correspond with vascular markings. Epiphyseal lines are often mistaken for fracture. Periosteal proliferation along interosseous membranes and along intermuscular septa must not be mistaken for true periostitis nor the roughening and slight proliferation which occurs at the attachment of tendons. There is normally roughening on the inferior margins of the pubic bone and on the ischial tuberosity. Calcareous deposits occur extensively in the body outside the bony structures. Solid concretions containing lime are found in the various organs especially the bile passages, urinary tract, appendix and salivary ducts and in certain

cysts. Cancellous bones sometimes exhibit small round areas of condensation and transverse lines along the medullary canal toward the ends of the long bones, the result of disturbances of growth.

The various anatomical variations which occur in bony structures must all be taken into account. Suture lines vary greatly and anomalous suture lines occasionally are seen. The facial sinuses and the mastoids vary from complete absence to very great size. Extra ribs and vertebral bodies or parts of bodies may be present or ribs may be absent or fused. Various accessory bones are present in the carpus and tarsus and these are often divided or tripartite. One sees cases of partial or complete absence of long bones or supernumerary bones especially extra fingers or toes.

**Fractures and Dislocations**—A roentgenographic study is indispensable in determining the presence and variety of fractures and the degree of separation, displacements and complications as well as the result of manipulation in adjusting the fragments. A negative diagnosis of fracture should never be made from the fluoroscopic study alone but the fluoroscope may be used to great advantage in reducing fractures and dislocations. When feasible films made in two positions at right angles are better than stereoscopic films. Some fractures cannot be positively demonstrated by means of ordinary x ray study for instance certain fractures at the base of the skull but submental vertex projections should show them. During the course of treatment x ray studies show the progress of repair and the proper maintenance of position and approximation of fragments.

It was formerly thought that there were certain fractures in the skull especially basilar fractures which might escape detection on x ray examination but the introduction of the rotating anode tube, high milliamperage technique and the general improvement of diagnostic apparatus have removed most of the difficulties formerly

considered insurmountable. If enough films preferably stereoscopic are made in various projections especially the submental vertex projection it is doubtful if any skull fracture could escape detection.

The roentgen ray study of a fracture should determine the type and definite location of the fracture, the relation of the fragments as to apposition, separation, overlapping, angulation, impaction, etc.

Particularly in the skull difficulties may be encountered in differentiating fracture lines from suture lines, diploic veins and blood vessel grooves. In fractures of the pelvis the sacrum should always be carefully studied for possible fracture. The epiphyses of the pelvis remain open sometimes until the twenty-fifth year. Vascular channels in the ilium occasionally resemble a fracture. Rib fractures may be overlooked even with the most satisfactory technique unless multiple films are exposed. Fractures of the costal cartilage may escape detection unless the cartilage is calcified. In every injury to the wrist or hand the carpal bones should be carefully scrutinized lest carpal fractures be overlooked. In all injuries of the ankle the entire length of the fibula should be explored. In trauma of the knee it is not possible immediately to demonstrate injuries to cartilage such as dislocated or fractured semilunar cartilage unless a small fragment of bone has accompanied the displaced cartilage but some months after the injury when calcification has occurred evidence of old damage to the cartilage may be recognized. In fractures of the hip joint the entire line of fracture is not always demonstrable and unless several films are made the extent of the fracture may be overlooked. In intracapsular fractures of the femoral neck the formation of visible callus is slow or it may not appear at all. A greenstick fracture overlooked at the first examination may become demonstrable later because of the formation of callus.

Interstitial emphysema due to the development of gas phlegmon is occasionally observed. Roentgen films furnish the earliest possible evidence of such a condition and it should be looked for in every wound where gas infection is a possibility. Gaseous infiltration into the soft parts emphasizes the

contours of muscular bundles. X-ray study in gas gangrene permits determination of the depth and outer limits achieved by the infection with precision not possible by clinical examination. Putrid abscesses may be recognized sometimes. X-ray treatment is clearly indicated in cases of gas infection.

Careful search should be made before as well as after the reduction of a dislocation to avoid overlooking associated fractures. Epiphyseal dislocations usually involve a fragment of the contiguous shaft. Separation of the tibial tubercle with thickening and irregularity of the epiphyseal lines (Osgood-Schlatter's disease) is sometimes difficult to differentiate from the normal tibial tubercle which may appear in two or three parts with more or less ragged contours. The same remarks apply to the epiphysis of the os calcis.

**Infections of Bone**—Normal bones are characterized roentgenographically by smooth regular outlines, homogeneous cortex and uniform consistency of the cancellous structures although the cortical thickness and the texture of the spongy bone may vary considerably in different persons.

Pathologic lesions of bones are manifested by alterations in size, outline and density. It is always important to associate the clinical history with the roentgen findings. In interpreting the roentgenographic observations in bone one should note involvement of the medulla or cortex, associated disease in the soft parts, whether the lesion is single or multiple, whether it involves the epiphysis or the joint or is confined to the shaft, whether it involves neighboring bone and whether it is destructive or productive or both.

Increase in the size of bones occurs in cases of osteomyelitis, tumors, simple cyst, fibrocystic disease, Paget's disease and syphilis. Reduction in the size of bone follows trophic disturbance, paralysis and disuse from any cause. Periosteal deposits, callus formation and bone tumors alter the outline of bones. Porosity (or the diminished density) follows disuse, infection or actual destruction from tumor growth, especially metastatic malignant growths, cystic disease or any one of a series of osteolytic lesions under which may be named bone cysts, osteolytic sarcoma, Brodie's abscess, giant cell tumor, chondroma, metastatic disease, rick-

ets fragilitas ossium multiple myeloma osteomalacia etc Among the osteoplastic bone lesions are exostoses osteogenic sarcoma Ewings sarcoma Garra's osteitis marble bones scurvy fibrosarcoma myositis ossificans ossifying periostitis osteitis deformans and hypertrophic osteoarthritis Osteomyelitis and tuberculosis as well as syphilis and myxosarcoma may produce both osteolysis and osteoplasia as may also mammary and prostatic carcinoma

*Osteomyelitis* produces a certain amount of destruction of the medulla and cortex with an extensive periosteal reaction and resulting formation of sequestra and irregular sclerosis of bone It rarely extends beyond the epiphyseal line The process may exist two weeks or more before any changes are revealed in the roentgen aspect of the bone A negative diagnosis of acute osteomyelitis or periostitis should never be given on x-ray findings alone When bone infections have become chronic they always give positive roentgenographic signs

*Tuberculosis* commonly attacks the epiphyses in younger persons and is characterized as a slowly progressive local destructive process without attempt at regeneration It is rarely found in the diaphysis In the early stages the only finding may be an effusion into the affected joint but the neighboring bones soon show rarefaction with characteristic blurring and loss of detail and later areas of destruction In the wrist and hand the rarefaction may be so severe as to reduce the density of the bones to that of soft tissue As the lesion progresses destruction of joint surfaces occurs with resulting ankylosis Tuberculosis sometimes occurs in multiple foci which later fuse as in the head of the humerus Spinal tuberculosis usually involves the intervertebral disks with destruction of the contiguous portion of the vertebral bodies causing collapse and kyphosis A fusiform paravertebral shadow due to the abscess may be the first evidence of spinal tuberculosis

*Syphilitic bone disease* is a combined osteolytic and osteoplastic process which may affect any bone at any age Usually it is noted as periostitis or as an irregular area of destruction Syphilitic periostitis is usually confined to the diaphysis extending to the epiphyseal line at both ends In the acute

stage there are multiple distinct laminae superimposed on the old cortex with an irregular outline of the free margin In chronic syphilitic periostitis these laminae become compact and as dense as the normal cortex and the contours of the surface of the enlarged bone become smooth This increased cortical thickness gives the appearance of bowing as in saber shin the cortical thickening occurs on the convex side while in cases of rickets it appears on the concave side Some forms of syphilitic periostitis cause a lace work pattern with strands of calcified material running out at right angles to the cortex resembling the sun ray lines of periosteal sarcoma *Gummatous changes* cause irregular areas of rarefaction This is characteristic in the skull where punched out areas may involve both tables In *congenital syphilis* a juxtaepiphyseal lesion occurring in the shaft is the most common x-ray finding associated with the formation of new bone along the shaft *Charcot joints* are characterized by intra articular effusion extensive destruction of the articular ends of the bones and a deposit of osseous debris in the dilated synovial sacs

Chronic osteomyelitis may be simulated by a number of diseases such as *actinomycosis* *Madura foot* *echinococcus* and *coccidioidal disease* Coccidiosis is most common in the bones of the extremity and when it occurs near a joint it resembles tuberculosis *Leprosy* *yaws* and *phosphorus poisoning* all simulate osteomyelitis in the roentgenogram

**Bone Tumors**—In differentiating *benign* and *malignant bone tumors* it may be said that when the contour of the shadow cast by an osseous tumor is unbroken with few exceptions the lesion is benign A sudden break in the contour of the shadow of a bone speaks for malignancy When invasion of surrounding tissue has taken place lack of definite demarcation of the invading portion of the tumor emphatically suggests a malignant lesion whereas if the invading portion continues its definite demarcation this encapsulation indicates a benign lesion Again with few exceptions defects in flat bone even large ones if characterized by smooth definitely outlined margins indicate a benign lesion whereas the malignant lesions are usually marked by indefinite or irregular serrated borders

Even the nature of benign tumors may sometimes be recognized from the roentgenographic characteristics by taking into account the resistance to the rays offered by the various tissues. Cartilage is practically invisible. Fibrous tissues cast a certain amount of shadow and bone causes a dense shadow. Many tumors consist of combinations of these tissues and their nature may be estimated according to their radiotranslucency.

Giant cell tumors, Ewing's tumors (sarcoma) and myeloma are conspicuous exceptions to the general rules for malignant and benign lesions.

**Giant cell tumor** appears as a single central lesion near the epiphysis of a long bone, tending to grow in all directions but sometimes showing the greatest growth along the path of least resistance, the medullary canal. The cortical bone bulges but rarely breaks and no invasion of soft tissue occurs except where a fracture has occurred. The lesion causes widening of the bone, presenting a lobulated outline divided by many trabeculations and readily invades the epiphysis in contrast to osteogenic sarcoma.

**Myeloma** a highly malignant lesion follows none of the above rules. The shaft of ribs and long bones may be expanded without a break in contour and without invasion of neighboring tissue. There are multiple round or oval defects, the size of a peanut or hazelnut punched out in appearance, having a predilection for rib, sternum, thoracic and lumbar spine and pelvic bones.

**Ewing's sarcoma (endothelial myeloma of bone)** is characterized by a diffuse infiltration with resulting widening and increased density of the cortex and an elliptical symmetrical expansion of the shaft near the middle of long bones. New bone formation predominates, giving rise usually to parallel (onion skin) but sometimes radiating spicules. Later both cortical and medullary destructive changes are seen. Invasion of the soft tissues by this neoplasm results in a shadow less definitely encapsulated than that cast by most benign tumors and yet not so promiscuously invasive as osteogenic sarcoma. Ewing's tumors usually respond readily to radiotherapy, though the ultimate prognosis is not so favorable.

**Osteogenic tumors** may be (a) benign

such as *osteochondroma* and *osteoma* which arise from the cortex by a pedicle, often presenting a cauliflower appearance, never invading or destroying bone. *enchondroma* usually multiple, most frequently found near the ends of the epiphyses in the hands, feet and long bones, simulating giant cell tumor or (b) malignant as in the various types of *osteogenic sarcoma*, subperiosteal and medullary, periosteal, sclerosing, telangiectatic and the undifferentiated types, the latter being entirely osteolytic, showing only loss of substance and no proliferation.

Resembling in roentgenographic characteristics the malignant lesions of bone may be chronic *sclerosing osteitis*, the non-suppurating *osteomyelitis of Garre*, *traumatic osteoma*, *subperiosteal hematoma*, *osteitis fibrosa cystica*, *osteitis deformans*, *costoses* and generalized *xanthomatosis* of bone.

*Osteochondritis deformans juvenilis* (Perthes disease), chronic slowly progressive *osteitis of the semilunar bone* (Kienboeck's disease), *Köhler's malacia of the tarsal scaphoid bone in children* (or navicular pedis retardatum) and several other similar chondral lesions are demonstrable with roentgen studies.

**Metastatic Tumors**—Carcinoma in bone is always metastatic and generally multiple, involving any one or all of the bones. It is not often found in the extremities below the knees or the elbows. Osteoclastic forms predominate, producing a moth eaten appearance due to irregular destruction of bone substance with no periosteal reaction and no change in contour unless pathologic fracture occurs. In the osteoplastic form, which is usually secondary to prostatic or mammary carcinoma, there is extensive production of dense bone with coarse mottling due to intermingled areas of rarefaction and condensation and sometimes with enlargement of the bones suggestive of *osteitis deformans*. Metastases from hypernephroma have a predilection for bones. Malignant disease of the testicle and of the bladder rarely metastasizes to bone. Approximately 6 per cent of uterine and 3 per cent of ovarian malignant tumors cause skeletal metastases. Bone metastases are encountered in about 1 per cent of the cases of malignant diseases of the digestive tube and in about 15 per cent



cases of malignant disease of the lung Lymphosarcoma may metastasize to bone and osteogenic sarcoma may present multicentric growths Pathologic fractures are often discovered in metastatic bone lesions

**The Head and the Skull**—By the injection of air into the spinal canal (encephalography) and the injection of air into the ventricles through small trephine openings in the parieto occipital regions (ventriculography) new aid is rendered in the demonstration of *intracranial tumors* and post inflammatory or post hemorrhagic *cicatricial lesions* which distort the ventricles or obliterate the subarachnoid spaces In the spinal canal the injection of air or opaque media permits the localization of *spinal cord tumors* and other causes of *compression of the cord* A *brain tumor* sometimes causes changes in the skull which are recognizable in simple films without the aid of ventriculography or encephalography Calcification in the mass itself is rare but it occurs just often enough to be tantalizing Localized erosions dilated vascular channels in the inner table of the skull irregular osteoporosis when lesions are situated in or near the calvarium new bone formation in the dura and displacement of a calcified pineal gland are other signs seen in cases of brain tumors Growth in the cerebellopontile angle may erode and push forward the posterior clinoid process

Deformity of the *sella turcica* is also seen in cases of generalized increase of intracranial pressure and intrasellar tumors In *acromegaly* there is enlargement of the sinuses elongation of the mandible a general increase in size of the bones of the hands and feet and coarsening of the texture of spongy bone in general in addition to the local destructive changes consisting of spherical enlargement and thinning of the sella sometimes with perforation of the floor and altered contours of the posterior clinoid process

Premature closure of the cranial sutures early in life causes the striking picture of tower skull or turret head (*oxycephaly*) showing an abnormally high and broad skull with numerous crescentic markings in the inner table corresponding to convolitional pressure atrophy (*uniones digitorum*)

*Hydrocephalus* enlarges and thins the

vault of the skull exaggerates the convolutional impressions sometimes separates the sutures and flattens the sella Ventriculography shows remarkable ventricular dilatation and reduction of the thickness of the cortex

Roentgenography of the accessory sinuses constitutes a subject which cannot be dealt with in a paragraph In roentgenograms made for the sinuses one may recognize thickening of the lining membranes by a generalized uniform haziness tumors such as osteoma or polypoid growth malignant disease empyema and other lesions

Acute *mastoiditis* causes general haziness of the affected cells with blurring of their marginal contours More advanced cases show destruction of cells and loss of detailed outlines with an indefinite area of increased density Comparison of the two sides is helpful anomalies are usually bilateral Chronic cases show more or less absence of cells and a certain amount of sclerosis

*Dental film studies* supplemented when necessary by extrioral roentgenograms of the lower jaw aid in the detection of dental foci of infection The following are the principal lesions shown in relation to the teeth apical periodontitis granuloma apical chronic abscess with scar bone walled off abscess or erosion of the tip of the root root cyst osteomyelitis necrosis and sequestrum formation pathologic change in the pulp and periodontal disease

*Salivary calculi* cast dense oval or rounded shadows in the position of the salivary glands or their ducts Much technical ingenuity is required to demonstrate such calculi Sialography by the introduction of opaque oil through a cannula into the duct of the affected salivary gland is often very useful in diagnosis

The jaw is subject to the same diseases seen in bone elsewhere Special mention should be made of the following conditions

a *Root cysts* appear as single or multiple rounded areas of rarefaction They are well demarcated enclose the roots of one or more teeth and show little or no trabeculation

b *Dentigerous cysts* are similar but since they develop from a buried tooth germ they usually contain teeth

c An *odontoma* is seen as a dense mass of dental tissues attached to a tooth or com-

posed of a compact fused mass of several teeth.

d An *adamantinoma* forms a large slowly developing mass containing multiple small cysts sometimes calcified which expands the alveolar process. These growths do not metastasize. Occasionally there is a solid form of this tumor.

#### LOCALIZATION OF FOREIGN BODIES AND REDUCTION OF FRACTURES

Localization of foreign bodies under x-ray examination has been brought to a high degree of perfection through the immense practice gained during World War I. When the foreign body is large enough to be seen on the screen fluoroscopic localization marking localizing points on the skin with indelible ink gives the most prompt and satisfactory service to the surgeon. Numerous localization methods are described in the literature<sup>1</sup> but space here will not permit a description of them. Film records in two or more directions, stereoscopic films and films made after the introduction of needles into the soft tissues in the vicinity of the foreign body and left in place during the operation as well as during the x-ray study are all means at the command of every hospital. Simple fluoroscopic methods of accurate localization which may be employed with any standard type of fluoroscope have been described by Gilbert and Hertenstein<sup>2</sup> and the method provided with the U. S. Army table unit has been set forth by de Larosier.<sup>3</sup>

Utilization of the fluoroscopic screen during extraction of opaque foreign bodies is not sufficiently appreciated by American surgeons, especially the younger men who did not have an opportunity for war service. One of the operating staff must use dark glasses to protect his eyes from light or else the preliminary exposure of the field must be obtained with a red light to preserve the surgeon's accommodation. The operation must be performed in the x-ray fluoroscopic room on the standard fluoroscopic table, or a portable x-ray apparatus (preferably a shock-proof instrument) should be taken to the operating room and the screen observations made by one of the doctors using a bonnet type of fluoroscope. The x-ray apparatus in use should be calibrated under

the conditions employed in the actual operation as to accurately measured target film distance, milliamperes, voltage and the output in roentgens per minute and by means of an integrating time clock, careful watch should be maintained so that no skin area receives more than 300 roentgens. A foot switch should be employed and the current turned on only after the surgeon's eyes have focused on the screen, not a second of screen illumination should be wasted. The opening in the diaphragm should be as small as possible and sufficiently long instruments used so that the operator's fingers are never exposed. Specially devised forceps for the extraction of foreign bodies are available. Removal of a foreign body is often of minor consequence in the treatment of war wounds.

The reduction of fractures under fluoroscopic control involves the principles just described. No surgeon should resort to fluoroscopic control of reduction manipulation unless it is quite impossible to do without it; otherwise he will sooner or later suffer damage from repeated exposures, however brief they may be. When this aid is required the observations should be made as brief as possible and a total skin dosage of 300 roentgens in an individual case should not be exceeded without a time interval of three weeks. Here too the field of screen illumination should be as small as is compatible with expeditious work. An aluminum filter of from 0.5 to 1 mm thickness is absolutely necessary for safe fluoroscopic work.

#### THE THORAX

Roentgen interpretation of intrathoracic pathologic states must depend fundamentally on gross alterations of the normal shadows which may be recognized in the films or screen image. The large air content of the lungs enhances the visibility of the pathologic process. The screen study is of more value in the study of viscera in motion for noting deviations of organs or accumulations of fluid on change of posture and in the various respiratory phases and in the differentiation between transmitted and expansile pulsation. Films record finer details than can be recognized fluoroscopically.

The bones of the thorax are subject to the same diseases as skeletal structures elsewhere. Soft tissue emphysema may accom-

pain, the fracture of a rib or other injuries in which the lung is punctured.

The central shadow of the chest includes the pericardium and its contents and the great vessels, the thyroid if it extends into the thorax, the thymus when present and the root of the lungs. An *enlarged thymus* sometimes resembles a small heart capping the normal cardiovascular shadow, sometimes it presents a roughly quadrangular shadow. A *retrosternal extension of the thyroid* is usually broad in its upper portion, narrowing to the point of disappearance over the shadow of the great vessels; it frequently results in tracheal compression or deviation. Enlargements of the *tracheobronchial and other neighboring glands*, generally due to Hodgkin's disease, tuberculosis or metastases from malignant disease elsewhere in the body, present sharply defined irregular or lobulated shadows, often bilateral, without intrinsic pulsation, although the larger masses transmit pulsations from the heart or aorta. *Hodgkin's disease* is usually accompanied by glandular enlargements elsewhere. Radiation therapy supplies a therapeutic test, since under irradiation the glands rapidly diminish in size or disappear. *Lymphosarcoma* closely resembles Hodgkin's disease. *Malignant mediastinal tumors* show more irregularity of outline, tending to invade the surrounding tissues rather than to displace them. The presence or absence of pulsation has not been of much help in making a differential diagnosis. Some aneurysms do not pulsate, transmitted and expansile pulsations are not easily differentiated.

The various *valvular lesions of the heart*, when they have altered the size of the cardiac chambers, show more or less characteristic x-ray evidence which contributes to the accuracy of the clinical diagnosis. *Cardiac aneurysms* occur occasionally, usually in the ventricular region as a sequel of coronary infarcts and should be recognized. Calcifications of the cardiac valves are more easily discovered on the screen than they are on roentgenogram.

*Syphilis* affects especially the root of the aorta, the mouths of the coronary arteries and the aortic cusps; the aortic shadow bulges markedly to the right, pulsates prominently and is definitely increased in diameter.

In *arteriosclerosis* the heart may show no change or may be enlarged to the left and the aortic shadow is increased toward the left with marked prominence of the aortic knob, sometimes showing dense calcareous plaques. The roentgen findings are often complicated by broken compensation with resulting pulmonary circulatory stasis and evidence of small fluid accumulations in one or both costophrenic angles.

In *pericardial effusion* the heart shadow is triangular with the apex pointing toward the region of the great vessels, giving a water bottle shape to the heart shadow, especially when the patient is in an upright position. Cardiac pulsation is greatly diminished or absent when it is distinguishable; the impulse is more or less general over the entire left border without distinction between the auricular and ventricular pulsation. Amounts of pericardial effusion even up to 200 cc. may escape observation. The differential diagnosis between cardiac dilatation and pericardial effusion depends chiefly on the presence or absence of the altered shape of the heart shadow when the patient's position is changed.

*Aneurysms* of the ascending aorta show bulging of the aortic shadow to the right; those of the arch appear higher up and to the left and those of the descending portion to the left, more or less superimposed on the cardiac shadow. The position of the aneurysmal sac is of the greatest importance. Diffuse dilatations of the aorta are aneurysmal in character but involve the entire thoracic aorta. Tortuosity of the aorta may simulate diffuse dilatation or aneurysm. The paravertebral fusiform shadow due to the abscess of Pott's disease should not be confused with aneurysm.

*Mediastinal pleurisy or abscess* is best distinguished by lateral study of the chest. The shape of the shadow does not change with respiration or with the position of the patient; indeed the movements of the diaphragm are limited or paradoxical.

*Hernia of the diaphragm* shows roentgenologically as a cyst like mass above the diaphragm, usually the left, containing air or fluid or both. The nature of the lesion is studied by an opaque meal and at times by an opaque enema. By using every device of fluoroscopy in various positions and at vari-

ous angles it will be possible to differentiate a hernia through the esophageal hiatus from a hernia through an acquired or congenital rent in the diaphragm and to determine the approximate size and position of the rent as well as to recognize eventration of the diaphragm.

*Subphrenic abscess* shows elevation and limitation of movement of the diaphragm on the affected side and later secondary supraphrenic pulmonary and pleural involvement. In perhaps a third of the cases the abscess cavity contains gas which causes a fluid level to form that can be determined by a study made in the erect or lateral position. A subphrenic abscess may be simulated by encapsulated fluid just above the diaphragm and by an abscess of the liver or a subhepatic or perinephritic abscess.

*Pulmonary tuberculosis* is rarely present without sufficient gross change in the tissues to produce shadows on the roentgenograms. This is more true of adults while for infants peribronchial tuberculosis may entirely escape roentgenologic detection. The interpretation should be conservative undoubtedly in many cases an incorrect diagnosis of pulmonary tuberculosis has been made because too much pathologic evidence was read into x-ray films of the chest. Any operation on the chest looking to the cure of pulmonary tuberculosis should be rigidly controlled at intervals by x-ray observations.

*Postoperative pulmonary complications* should be more frequently controlled by bed rest and x-ray studies. *Lobar pneumonia* is characterized by clearly defined areas of homogeneous increased density which partially or completely occupy the position of pulmonary lobes. There is at first a slight veil-like shadow in the central lung field associated with an accentuated peribronchial marking. The veiling increases in density as the exudative process advances. As resolution takes place there remains a distinct mottling which gives place to thickened bronchial markings or large glands. Pneumonic shadows are less dense than the shadow of the fluid. Fluid in fair amount displaces the heart and other mediastinal structures to the opposite side whereas lobar pneumonia causes no displacement. Respiratory motion and diaphragmatic excursion are reduced in lobar pneumonia.

In *bronchopneumonia* the relation of the single or multiple shadows of increased density to the larger bronchi is easily recognized. They rarely reach the pleura and they completely obliterate the lung markings only rarely. There is rarely any interference with the excursion of the diaphragm. Pulmonary circulatory stasis may simulate bronchopneumonia. An atypical bronchopneumonia not due to a pneumococcus and usually without leukocytosis has been generally accepted as *virus pneumonia*.

*Infects of the lung* show sharply defined areas of increased density, single or multiple without displacement of mediastinal structures or interference with the diaphragm. They are usually triangular in shape with the apex of the triangle pointing toward the root of the lung.

*Pulmonary abscess* usually follows an acute infection, aspiration of infected material (as at operation) or the inhalation of foreign bodies. Lung abscesses are usually single occurring more often at the bases especially the right and giving rise to irregular shadow areas which are denser at the center and fade out into the normal lung tissue. Cavity formation supervenes as necrosis occurs in the center of the density. When air is present in the cavity the fluid assumes a level which shifts according to the position of the patient. The associated bronchial markings are coarser than normal and the roots of the lungs are usually enlarged. Information should be sought concerning the presence or absence of an adherent pleura and the distance from the abscess to the nearest point of external approach. Tuberculous cavities are usually empty while ordinary abscess cavities usually contain some fluid. Confusing lesions are those of tuberculosis, bronchopneumonia and bronchiectasis. Multiple abscess may simulate metastatic malignant disease or bronchopneumonia.

*Pleural effusions* collect in the most dependent part of the thorax causing a very dense shadow which obscures the ribs and the diaphragm. In simple hydrothorax the upper border of the shadow curves upward toward the chest wall in the axillary line. In hydropneumothorax there is a fluid level which changes according to the position of the patient. When the effusion is extensive

displacement of the mediastinal structures occurs toward the opposite side and there is evidence of compression of the lung. Fluid which develops in bedridden patients sometimes becomes encapsulated and produces a sharply defined shadow along the axillary border. Collections of interlobar pleural fluid may become encapsulated showing better on lateral than on posterioranterior projection. In cases of unencapsulated pleural effusion without pneumothorax the shape of the shadow changes only sluggishly as the position of the patient is altered. Encapsulated fluid should be carefully localized so as to facilitate accurate surgical approach. The density of the shadow of pleural effusions is the same whether due to pus, serum or blood. Simple serous pleural effusions are rarely encapsulated; encapsulation suggests empyema.

*Pneumothorax* with the lung partially collapsed and the pleural cavity containing air may occur spontaneously with little or no evidence of pulmonary disease. The lung markings are absent in the pleura outside the contracted lung. If no pleural adhesions are present the lung appears as a lobulated central mass but when adhesions have formed the collapse is incomplete. This is true both in spontaneous and in artificial pneumothorax.

*Pleural calcifications* cause ragged dense flat or linear shadows corresponding to pleural sites.

*Bronchiectasis* is characterized by extensive thickening of the lung markings usually along the larger descending branches of the bronchial tree with enlarged root glands and diffuse clouding in the lower portions of the lungs sometimes showing multiple small fluid levels corresponding to the various bronchiectatic cavities. Emphysema may be an associated finding. The introduction of iodized oil into the bronchi reveals the exact location and size of the bronchiectatic cavities.

*Foreign bodies* cause a surrounding area of increased density as a result of localized pneumonia, the formation of an abscess or the collapse of one or more lobes because of bronchostenosis. Sometimes the foreign body acts as a ball valve permitting air to pass into but not out of one or more lobes. Opaque foreign bodies are easily visualized

and localized but the presence of a non-opaque foreign body must be deduced from the fact that air can enter freely but its expulsion may be obstructed. During expiration the involved lobe shows emphysema with increased translucency to the rays; the diaphragm on the affected side is depressed and flattened and the heart may be displaced toward the opposite side. When the bronchus is completely obstructed the air in that portion of the lung is soon absorbed and atelectasis occurs resulting in density of the involved lobe, retraction of the thoracic cage, narrowing of the intercostal spaces, elevation of the diaphragm and retraction of the mediastinal contents toward the involved side. Such a condition of atelectasis involving all or part of a lung may occur during or after operation following the aspiration of a clot of mucus or other similar material. If the foreign body persists or if it consists of infected material inflammatory changes take place which resemble bronchopneumonia, consolidation, local degeneration and abscess may follow. The majority of aspirated foreign bodies occupy the right bronchus unless they are too large in which case they lodge in the trachea. A foreign body may lodge in one of the bronchi of the upper lobe if inhaled while the patient is horizontal. Fluoroscopy, especially biplane, may aid materially in the bronchoscopic procedures for removal of foreign bodies.

*Pleural malignant disease* is not easily diagnosed from the x-ray findings alone. It may be masked by the accompanying effusion. In suspected cases withdrawal of the fluid should be followed immediately by roentgen study at which a diffuse thickening may be the only x-ray evidence.

*Primary pulmonary malignant disease* is usually unilateral. The nodular type presents peripheral dense rounded masses sometimes with the formation of an irregular cavity. The infiltrated type follows the larger branches of the lung tree sooner or later advancing into the parenchymal tissue. Partial collapse may take place with the usual accompaniments of atelectasis; pleural effusion is seen early. Pulmonary malignant disease especially when primary is altogether too often unsuspected and overlooked.

*Metastatic malignant disease* is seen most commonly as multiple usually rounded

sharply defined densities of variable size scattered throughout both lungs. Sometimes pulmonary metastatic malignant disease causes a fine mottling diffuse throughout both lungs which is larger, more dense and more sharply defined than in miliary tuberculosis. Another type of metastasis begins in the bronchi with the development of large masses at the roots of the lungs and with effusion at one or both bases.

*Hydatid cysts* of the lung occur most often in the bases usually a unilateral single lesion but sometimes bilateral and multiple. There is often a shell of calcareous material surrounding the cyst. If rupture has occurred inflammatory reactions follow resembling lung abscess.

### THE DIGESTIVE ORGANS

Many gastrointestinal surgical lesions are roentgenologically recognizable because of some alteration of the normal morphology or function. It is therefore a prime essential that the roentgenologist should be thoroughly familiar with the fluoroscopic and roentgenographic anatomical and physiologic aspects of the normal digestive tract, a knowledge which can be gained only by abundant experience. Naturally the lumen of the digestive tract must be visualized either orally or rectally by the administration of some contrast substance usually barium sulfate sometimes supplemented by air inflation.

*Esophagus*.—Esophageal diverticula show an ovoid sac of greater or lesser size usually located to the left and posteriorly in the upper esophagus though epiphrenic diverticula do occur. The opaque medium passes readily down the practically unobstructed esophagus alongside the diverticular sac. Regurgitation and aspiration of the barium may occur with visualization of the bronchial tree. A congenitally short esophagus with a portion of the stomach above the diaphragm may be confused with hernia of the stomach through the esophageal hiatus or a supraphrenic diverticulum.

*Esophageal carcinoma* is characterized by tortuous or irregular contours of the stenosed lumen with some dilatation above the stenosis usually less marked than in cases of benign obstruction. Antiperistalsis is often seen in cases of obstruction. A rough or indented

filling defect of the esophageal lumen proportionate to the size of the growth may be demonstrated especially with the patient in the horizontal position.

*Cardiospasm* is marked by signs of obstruction near the cardia, the smooth symmetrical termination of the lower end of the dilated esophageal shadow showing a blunt or regularly conical contour as contrasted with the usual dentated aspect seen in carcinoma. The dilatation is often extreme and the contours of the upper part of the esophagus are marked by contraction waves often with antiperistalsis or spasmodic constrictions.

Spasm may occur anywhere in the esophagus as a reflex result of early carcinoma, be cause of gastric irritations or because of the presence of foreign bodies. Non opaque foreign bodies may be recognized sometimes by fluoroscopic search for a point of temporary or lasting obstruction of barium.

Aside from the evidence of obstruction cicatricial stenoses following healed simple syphilitic or tuberculous ulcer, trauma or from swallowing caustic liquids do not give especially characteristic x-ray finding. The differential diagnosis must depend on the history. There is usually a rounded symmetrical smooth termination to the dilated esophageal shadow, a thin stream of opaque material trickling through the stenosis.

*Esophageal varices* are sometimes shown by using a barium sulfate-glycerin mixture or an aqueous solution of thorium dioxide (umbrathor).

*Stomach*.—Organic intragastric lesions are betrayed by a derangement of the normal symmetry of the gastric rugae by changes in size, mobility, motility, secretion or peristalsis and by persistent deformity of the luminal contour but such deformities as well as alterations of motility, tone and peristalsis are sometimes materially confused by spasm. Indeed spasm is chiefly accountable for some of the characteristic changes in form such as the spastic hourglass stomach in a case of ulcer and much of the deformity of the duodenal bulb in a case of duodenal ulcer. Spastic indentation of the greater curvature at the lesion's level diffuse spastic distortion or reflex pyloric spasm may occur in gastric ulcer. When reflex spasm is suspected an antispasmodic should

be administered to full physiologic effect. Spasm of any sort will disappear under the influence of a general anesthesia.

Distinct roentgenologic signs are present in 93 per cent of the cases of *gastric cancers* and include filling defects corresponding more or less to the size and shape of the tumor, alterations of pyloric function usually with gaping of the opening but sometimes with obstruction when the lesion is near the pylorus, absence of peristalsis in the area of the growth with weak or exaggerated peristalsis and at times antiperistalsis or irregular peristalsis depending on the nearness of the lesion to the pylorus, rapid and early emptying in non-obstructive cases and naturally a delay in cases with obstruction, lessened flexibility and mobility of the gastric wall and other less important signs. The type of malignant growth, colloid, fungous or scirrhous, is sometimes indicated by the character of the filling defect. Most 'leather bottle' stomachs are due to the diffuse infiltrative scirrhous type of carcinoma. The operability of a gastric carcinoma may often be estimated with great accuracy from the roentgen examination.

In gastric syphilis the roentgen findings are usually not characteristic and pathognomonic but taken together with the other laboratory and clinical evidence they should lead to a high percentage of correct diagnoses. A gastric filling defect usually without a palpable mass, an irregular concentric contraction producing an hourglass stomach and a discrepancy between the extent of the organic gastric involvement and the history and relatively good general condition of the patient.

*Other benign tumor producing lesions* of the stomach including myomas, fibromas, often polypoid and adenomas, and occasionally lipomas, cause filling defects which simulate carcinoma but lack the dentated contours. Tuberculosis of the stomach is very rare, as are angioma, dermoid cyst and generalized gastric polypoid.

Of *gastric ulcers* 90 per cent should be demonstrable at roentgen examination. It may be impossible to demonstrate simple ulcers since they are small, shallow and often slit like minute ulcerations, especially when not accompanied by indirect signs, such as spastic constrictions or retention. Penetrating

ulcers show a crater extending out from the gastric lumen, sometimes causing the formation of diverticula or accessory pockets which in the erect position may show an air bubble and hourglass formation. In direct signs include various spastic manifestations such as the incisive hourglass, spastic stomach or diffuse gastrosphincterism, diminished tonus, delayed emptying, weakened peristalsis and a point of tenderness corresponding to the site of the ulcer unless the ulcer occurs in the pyloric zone in which event the symptoms will resemble those of duodenal ulcer. An hourglass stomach is sometimes simulated by a 'cascade stomach.'

Various *foreign bodies* may be found in the stomach, the most interesting being the non opaque hair balls and phytobezors. *Diverticular sacs* are occasionally found in the stomach usually near the cardia where they may be mistaken for ulcers. *Diaphragmatic hernia* is fairly common either through the esophageal orifice (*hiatus hernia*) or through an actual rent in the diaphragm. In *congenital pyloric stenosis* roentgen study may demonstrate the degree of pyloric patency, the time needed for gastric evacuation and the presence or absence of dilatation and should aid in differentiation from pylorospasm.

*Following operation* roentgen study is indicated whenever the results are not satisfactory, especially after gastroenterostomy. Jejunal and gastrojejunal ulcers may show any one or more of the following signs: a persistent neck representing the crater of the ulcer, deformity about the stoma, diminished patency of the stoma with gastric dilatation and gastric retention, deformity and narrowing of the efferent loop, gastric hyperperistalsis, duodenal dilatation and the concurrence of a point of pressure pain with the stoma.

**Duodenum and Small Intestine**—The chief duodenal lesions demonstrable on x ray study are listed below together with the chief roentgen signs.

In *duodenal ulcer* distortion of the duodenal bulb almost always occurs, often quite out of proportion to the organic changes found at operation. The bulbous deformity is chiefly the result of intrinsic spasm, supplemented by edema and inflammatory infiltration. Persistent resemblance of the bulbous

outline to a pine tree or a bit of branched coral the deformity involving one or both lateral borders almost always indicates the presence of a duodenal ulcer. Other deformities involve the basal border of the bulb others are of the niche type still others are of the incisura type perhaps with an hour glass duodenum. Accessory pockets or sacculations are also seen following invasion of the ulcer into the periduodenal tissues. In a very large percentage of cases a constant deformity of the duodenal bulb is pathognomonic of duodenal ulcer but such deformities may also result from periduodenal or pericholecystic adhesions or from cancer of the duodenum. Deformity of the bulb may also occur from extrinsic spasm as from gall bladder or pancreatic disease.

Obstructing duodenal ulcer causes gastric stasis and hypertrophy with gastric dilatation. In such cases hyperperistalsis alternates with periods of almost complete absence of peristalsis. Hypertonicity, hyperperistalsis and hypermotility constitute the triad of important indirect signs of non obstructing duodenal ulcer. Sometimes hypermotility is noted during the early minutes or first half hour of digestion followed by delayed emptying as pyloric spasm and hyperacidity develop.

*Duverticula* of the duodenum or upper small intestine are chiefly non symptomatic although occasionally one is found with diverticulitis or a peridiverticular inflammatory response. In very few cases of Meckel's diverticulum has the sac been demonstrated roentgenologically though the obstructive complications may be recognized if they exist.

A special technic with umbrathor or a similar preparation for visualizing the rugae and the use of compression and multiple films are required to demonstrate carcinoma or other tumors of the duodenum but with this technic the filling defect caused by the tumor even when small may be shown. Encroachment of periduodenal cancer as of the pancreas or peritoneum may also be shown by serial studies with careful compression technic.

Obstruction of the small intestine from various causes may be shown by means of x ray study after the ingestion of an opaque substance (1 ounce of barium sulfate sus-

pended in glucose solution or a dilution of umbrathor) indeed in acute cases the obstruction and its approximate site may often be determined by the disposition of gas and the level of fluid as shown by a simple film of the abdomen. Carcinoma of the small intestine has recently come well within the field of successful roentgen diagnosis but its recognition demands patient frequent study at half hour intervals with compression technic once the probable site of the lesion has been made out. The addition of intestinal intubation with the administration of opaque material through this tube when it has reached the approximate site of the lesion still further adds to the prospect of success. The x ray aspect of a small intestinal obstruction may be simulated by obstructive lesions of the colon even those occurring as far over as the left third of the transverse colon. *Tuberculosis of the terminal ileum* is characterized by extreme irritability or inhospitability so that the affected segment refuses to retain its opaque content. The cecum often shares this irritability giving rise to Stierlin's sign. In later stages hypertrophic lesions develop with obstruction. *Regional ileitis* is often multiple involving several segments of the ileum usually the terminal portion distal to each dilated segment the narrow ileac lumen is recognized by the string sign.

*Colon*—The colon varies greatly as to length diameter disposition in the abdomen and mobility. Redundancies are common and not necessarily pathologic especially in the sigmoid flexure. Positions and configurations vary from hour to hour as seen at successive examinations. The haustral contractions especially emphasized in the transverse and descending portions of the large intestine are seen prominently also in the cecum and ascending colon. They are more pronounced when the colon is visualized by a barium meal than by an opaque enema but if the enema is retained for a short time the haustral markings usually become quite prominent. After an opaque meal the haustral markings disappear momentarily at the time of spontaneous mass or transport movements. Several grades of colitis such as may be present in tuberculosis chronic ulcerative colitis and various forms of dysentery are character-



ized by the persistent absence of the haustral markings and by hypermotility. Displacement of the colon may sometimes give a clue as to the identity of intra abdominal or retroperitoneal tumors *e g* splenic tumors displace the left flexure of the colon downward whereas renal tumors usually elevate it and spread apart its loops.

The concentric or unilateral filling defect due to *carcinoma* of the colon is irregular and constant and maintains its site in the colon regardless of manipulations during palpation. The combination of an opaque enema and injection of air may reveal details concerning the exact extent of the lesion that are not recognizable with the simple opaque enema technique. The filling defect in cases of colonic carcinoma may be simulated by gas or fecal matter spasm, an insufficient quantity of the opaque enema, pressure of extrinsic tumors neighboring viscera or bony parts, adhesions and especially such gross lesions as tuberculosis and diverticulitis of the colon. The inflammatory thickening attending diverticulitis may produce both a filling defect and obstruction and unless at least a few of the diverticular sacculations are discovered it may be impossible to make a differential diagnosis. The filling defects due to tuberculosis usually involve the proximal colon often with the terminal ileum and there is a surprising lack of palpable mass in consideration of the apparent size and extent of the lesion. Colonic carcinoma may be simulated by pericecal abscess associated with appendicitis and by actinomycotic polypoid syphilitic and non specific granulomatous lesions.

The early stages of *diverticulitis* may be recognized by mucosal herniations and enterospasm most marked in the sigmoid colon. Symptomless colonic diverticula (diverticulosis) are common when associated with enterospasm, abdominal pain (often of great severity), constipation, vesical symptoms and in many cases a palpable tumor. The recognition of diverticulitis becomes a matter of importance. Complications such as fistulas, perforation, peritonitis, abscess formation, adhesions and superimposed carcinoma may complicate the roentgenologic findings.

In intestinal tuberculosis the chief roent-

gen finding is the filling defect due to the ulcerative and inflammatory process plus the spastic manifestations. The haustral markings are usually absent and hypermotility is of extreme grade unless the process has reached an obstructive stage. *Chronic ulcerative colitis* and *intestinal polyposis* are best studied by the combined opaque enema and the injection of air which may permit the identification of individual ulcers and polypi, especially in stereoscopic films.

The normal appendix receives and evacuates the barium meal when given by mouth within the time necessary for evacuation of the cecum. By opaque enema the appendix may not at first become visualized but if observations are made after a few hours some of the retained opaque enema will find its way into the normal appendix. Roentgen signs of a pathologic appendiceal condition: adhesions, persistent kinking, concretions, localized pressure-tender point, localized narrowing of the lumen and absence of the appendiceal shadow.

*Intestinal intussusception* should be recognized by the opaque enema which sometimes in acute cases serves to unfold the intussuscepted bowel. Chronic intussusception may cause a large filling defect which is easily confused with carcinoma of the colon. *Congenital idiopathic dilatation* of the colon is easily recognized by the opaque enema and in most cases it is not necessary to administer any opaque material, the condition being betrayed by the gas-outlined contours of the dilated segment.

*Postoperative gastrocolic fistulas* and fecal fistulas from other causes such as abscesses or injuries to the intestinal wall are profitably studied with the x ray after appropriate visualization of the sinus tract by opaque oil or by the routine barium meal or enema.

**Peritoneal Cavity** —For a time roentgen study after *artificial pneumoperitoneum* by the introduction of air or gas into the peritoneal cavity was highly recommended as a method of differentiating intra abdominal and retroperitoneal tumors but its popularity has faded until today it is a rarely indicated but nevertheless at times valuable diagnostic aid. This is especially true in countries where hydatid disease is prevalent. Spontaneous pneumoperitoneum may be a

sign of rupture of a hollow viscus as by perforation of an ulcer.

**Liver and Gallbladder.**—Plain films show the size of the liver and its shape. Gallstones are revealed if they contain lime and rarely does the gallbladder show by calcification of its walls. Attempts to discern the gallbladder shadow on plain films or estimate gallbladder impressions in the duodenal bulb are likely to lead to much error because the duodenum itself may cast an avoid shadow resembling the gallbladder and pressure defects in the duodenal bulb may be made by a lobe of the liver approximating the gallbladder in size and shape. Even if a shadow is cast by the gallbladder, that is not sufficient basis for believing the gallbladder to be pathologic. Shadows suspected of being gallstones should be carefully differentiated from right renal stones by intravenous or retrograde pyelography or by plain roentgenograms made at an oblique projection so as to cast the shadow outside of the shadow of the kidney from calcified mesenteric glands whose shadows are usually multiple and have a resemblance to mulberries and from calcifications in the chondral portions of the ribs.

Graham Cole Copher and Moore in 1923 discovered that it is possible to administer in the late afternoon either intravenously or orally 3 or 4 Gm of tetraiodophenolphthalein (for *cholecystography*) and show the gallbladder in films made the next morning on food other than carbohydrates being taken meanwhile. The resulting cholecystograms normally show the uniformly dense shadow of the gallbladder which empties within one half to two or three hours after a meal containing fat. Cholesterol gallstones show as defects in the gallbladder shadow somewhat suggestive of vacuoles in an ameba unless the cystic duct is blocked in which case no dye enters the gallbladder and "absence of shadow" is noted. When no shadow can be found there is a 90 per cent probability that cholelithiasis is present (75 per cent of absence of shadow cases showing gallstones) and a 10 per cent probability of extracholelithiasis disease of the biliary tract. Faint or distorted shadows may indicate pericholelithiasis adhesions and other non calculous cholelithiasis.

*Cholangiography* is often useful in study

of the common duct. In cases of biliary fistula a 50 per cent dilution of diodrast or meglumine or up to 25 cc of thorotrast may be introduced into the fistulous opening so that one can visualize the common duct determine the absence of stones from the duct or the papilla of Vater or exclude other types of common duct obstruction. The retrograde passage of the opaque material into the biliary radicals does not appear to be in any way harmful.

*Cholangiography* may be performed during operation by injecting the opaque material either into the gallbladder or into the common duct. A film previously placed under the patient is exposed by properly grounded bedside x-ray equipment used in the operating room with special precautions against explosions depending on the anesthetic employed.

Visualization of the liver and spleen (*hepatosplenography*) by the intravenous introduction of thorotrast may on rare occasions be indicated especially when it seems important to demonstrate the presence or absence of malignant disease of the liver. Because of possible dangers inherent in the use of thorium dioxide the method must be restricted to cases in which the patients are in the middle or older age groups and to cases in which in the presence of definite malignant disease there is the pertinent question of metastatic involvement.

#### URINARY TRACT

Probably 99 per cent of all renal and ureteral stones will show on a plain film a smaller proportion of cystic stones will be found. Many shadows lying along the course of the urinary tract must be differentiated the principal ones of a very long list being gallstones, calcified mesenteric glands, appendiceal calculi, tuberculous foci in the kidney, calcifications occurring in the pancreas, in hematomas or in old abscesses, unabsorbed opaque pills and other foreign bodies in the intestine. Plain films should also demonstrate the contour, size and relative position of the kidneys, the outlines of the psoas muscles and the outline of the bladder. Distortions of the psoas muscles are observed in psoas abscess or in paravertebral tumors of any kind and in perinephric abscess.

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**Peritoneal Cavity**—For a time roentgen study after *artificial pneumoperitoneum* by the introduction of air or gas into the peritoneal cavity was highly recommended as a method of differentiating intra abdominal and retroperitoneal tumors but its popularity has faded until today it is a rarely indicated but nevertheless at times valuable diagnostic aid. This is especially true in countries where hydatid disease is prevalent. Spontaneous pneumoperitoneum may be a

Visualization of the urinary tract may be accompanied by retrograde introduction through ureteral catheters of an opaque medium such as sodium iodide or by intravenous administration of some substance prepared for intravenous urography. All films should be exposed during expiration to avoid errors in the diagnosis of ureteral kinks. Before injection of the chosen contrast material a sensitivity test should be made.

Urographic study by one of these methods demonstrates renal anomalies such as horseshoe or ectopic or double kidney or ureter distortions of the renal pelvis by pressure of extrinsic tumors or enlarged adjacent organs *hydronephrosis* in every degree of change from the simple blunting of the calices to the formation of a large sac *pyonephrosis* with the principal change in the major calices which at first show irregular moth eaten edges and later rounded dilatations at their extremities and distention of the renal pelvis *tuberculosis tumors polycystic kidneys* or unipolar renal cysts.

*Congenital ureteral obstructions* usually by aberrant blood vessels at or just below the ureteropelvic junction are sometimes characterized by kinking of the ureter often with an indentation corresponding to the blood vessel itself the resulting dilatation is extensive in the pelvis and comparatively moderate in the portion of the ureter above the blood vessel.

*Renal tuberculosis* in its early stage can be distinguished only by areas of cortical necrosis later irregular dilatation of the pelvis obliteration of one or more of the calices and ureteral stricture are seen. The apices of the calices are most frequently involved showing an indistinct moth eaten outline sometimes with detached opaque areas in the renal substance.

Intrinsic tumors such as *neoplasms polycystic* *simple solitary cyst* and *hydatid cyst* are discovered in pyelograms when they alter the normal outline of the renal pelvis or calices. Alveolar carcinoma produces greater pelvic deformity than does *hypernephroma* (papillary adenocarcinoma). Neoplasms may elongate the pelvis or one or more calices they may encroach on the lumen of the pelvis to the extent of causing flattening or even obliteration of the pelvis

and narrowing of the calices there may result an abnormal position of the renal pelvis deformity of the ureter or even its complete occlusion in its upper portion or at the ureteropelvic junction. There is nothing characteristic in the roentgen findings in cases of benign tumors to distinguish them from other forms of neoplasm unless the lesion is accompanied by ulceration and tissue destruction.

The roentgen findings in a case of *polycystic kidney* include shortening or effacement of one or more calices resulting in an oval or irregularly squared pelvic contour. The extension or compression of cysts may cause one or more calices to assume a circular partly circular or broad elongated outline changed in relation to the axis of the pelvis. These findings may be complicated by secondary infection and inflammation. *Simple cysts* sometimes result in striking deformity of the renal pelvis and calices with shortening and compression of the calices and that portion of the pelvis adjacent to the cyst and displacement of the kidney in relation to its normal position and axis. Pressure of an *extrarenal tumor* may closely simulate this deformity. *Hydatid cysts* are usually marked by calcareous deposits in their periphery. Daughter cysts may sometimes be detected.

Urography is a valuable aid in identifying suspicious shadows. One should consider the distance of the shadow from the renal or ureteral outline and the exact relation of the shadow to the visualized urinary tract. Comparison of the plain roentgenogram showing a stone in the region of the kidney or ureter with another roentgenogram after pyeloureterography will improve the accuracy of localization. It is important to determine whether the stone is situated in the true pelvis in a calyx or in the cortex. The use of *roentgenography at the operating table* during the course of the operation is useful in determining the number of stones their position and whether or not the operative procedure has left behind any of the calculi. A straight lateral roentgenogram of the region will sometimes decide the identity of a suspected shadow which in the case of a renal calculus will lie well back superimposed over the vertebral shadow. The identification of suspected ureteral stones is ac-

complished by introduction of an opaque ureteral catheter or by visualization of the ureter with retrograde or intravenous uerography. The ureterograms in the case of ureteral stone will show complete inclusion of the suspected shadow in the shadow of the ureter dilatation of the ureter above the stone nodular dilatation of the ureter at the site of the stone or with retrograde pyelography dilatation of the ureter below the stone. Stereoscopes are sometimes of value in determining the relation of the suspected shadow to the ureter when visualized with opaque catheters.

Visualization of the bladder (cystography) by filling it with some opaque medium such as neosilol or in the course of intravenous urography is valuable in studying the extent of a neoplasm in the study of *diverticula* as to size and capacity for emptying and in the demonstration of *uretero-vesical insufficiency* vesical obstruction or deformity from pressure from without the bladder. Gaseous media are objectionable for cystography because they may be injurious and the uncertainty of the outline may be confused with gas in the intestinal tract. *Prostatic hypertrophy* is sometimes profitably studied in this manner especially intravesical hypertrophy.

*Urethrography* is occasionally of value but it cannot replace direct inspection through the urethroscope when it is feasible. Stricture of the urethra with urethral diverticulum and urethral fistulas may be profitably studied in this manner.

#### OBSTETRICAL AND GYNECOLOGICAL ROENTGENOGRAPHY

The principal indications for *obstetrical roentgenography* are the diagnosis of a doubtful pregnancy, the determination of presentation and position, the recognition of multiple pregnancy, the question of intra uterine death of the fetus, the diagnosis of extrauterine pregnancy, the determination of pelvic and fetal measurements and the study of suspected or evident disproportion and the investigation of the cause of polyhydramnios having in mind especially the possibility of fetal abnormalities.

Theoretically after the ninth week it should be possible to demonstrate on good x ray films some part of the fetal skeleton

but practically it is not possible to secure routinely satisfactory results before three and one half months i.e. three to six weeks before the appearance of definite clinical signs of fetal life. Near the end of gestation good roentgenograms should reveal even the fetal phalanges and sometimes the carpal and the tarsal. The perfection of the Aschheim Zondek reaction has diminished considerably the need of resorting to other means for the early diagnosis of pregnancy. Visualization of the fetus by injecting through the anterior abdominal wall into the amniotic sac a preparation of strontium iodide (*amniography*) is sometimes useful as in the diagnosis of *placenta praevia*. For the diagnosis of pregnancy it is not a justifiable procedure.

*Harm to the fetus* is not a danger attending ordinary diagnostic roentgen studies such as the determination of pregnancy, studies relative to obstetrical problems and gastrointestinal spinal and pelvic examinations but actual exposure to the x rays should be minimized.

Roentgen measurements of the pelvic diameters can be taken without any special apparatus the ordinary x ray equipment of a hospital should be satisfactory. Space here does not permit description of the technique of *pelvic and fetal mensuration*.

*Fetal monstrosities* are sometimes discoverable before delivery especially *anencephaly*, *double monstrosities*, *hydrocephalus* and other skeletal defects. *Litho-fetion* shows as a nearly round calcified mass simulating a calcified fibroid. *Ovarian and ectopic pregnancies* may occasionally be recognized especially if uterograms following the introduction of iodized oil into the uterine cavity supplement the ordinary x ray study.

*Death of the fetus in utero* may be betrayed by overlapping of the cranial bones which does not occur in labor until after engagement of the fetal head by spinal angulation, thoracic collapse and decalcification of the fetal skeletal parts as well as by a disproportion between the calculated age of the fetus and the supposed duration of gestation.

*Birth fractures and anomalies of skeletal structures* of the newborn child as well as anomalies of the digestive tract, diaphragmatic hernia and transposition of the viscera

are of interest. Reference has already been made to studies of the *thymus Atelectasis* is recognized by collapse of the affected lung with displacement of the mediastinum toward the affected side and elevation of the diaphragm on the affected side. Intravenous urography furnishes valuable aid in studying the urinary complications of pregnancy.

By means of a combination of roentgenography with pneumoperitoneum and intrauterine injections of iodized oil valuable aid may be given in *gynecological diagnosis*. Plain roentgenograms are not often of value except in the demonstration of *calcified fibroids and calcareous deposits in cysts and other ovarian tumors*. Calcified fibroids show well but even when not calcified they may be recognized by the displacement of intestinal loops visualized by the opaque meal or enema.

*Patency or stenosis of the fallopian tubes* and visualization of the pelvic viscera may be established by the peruterine introduction of air or oxygen into the peritoneal cavity. Tubal occlusion may be localized by the intrauterine injection of iodized oil. The combined use of trans-uterine intraperitoneal injections and iodized oil intrauterine injections is occasionally of value in solving special problems. Carcinoma of the uterine fundus should contraindicate attempts at peruterine injections. Double uterus and other uterine deformities are best demonstrated by the use of opaque oils.

Examination of the lungs and other parts of the body for evidence of metastases is especially important after operations on the breast, uterus and kidneys for malignant disease.

### ROENTGEN THERAPY

The factors governing the therapeutic administration of x rays are too complex for adequate presentation in a brief space. The use of radium and x rays is recognized universally as the third member of the triad of agencies which have proved most useful in the treatment of malignant diseases, viz. surgery, the cautery and radiation therapy. Long wave (soft ray) therapy for the destruction of superficial malignant growths and other lesions of the skin has been discussed in another chapter and the following discussion will be devoted to deep x ray therapy.

Deep x ray therapy means the use of short wave x rays at 200 000 volts or higher. Its efficiency depends to a considerable extent on the thickness and kind of metal filter used to screen out the less penetrating radiation which cannot reach the depth of the treated tissues and which can only harm the skin. The percentage of radiation which reaches the deep tissue is enhanced by a maximum target skin distance by the use of larger portals of entry (treatment fields) by greater milliamperage (intensity) and by cross fire. Cross fire is obtained by treating the objective lesion through several different areas of skin directing the radiation through each one toward the lesion. The time factor is important as a dose which may be sufficient if administered within a certain time may be altogether inadequate if spread out over too long a period. Increasing the intensity of the radiation (the milliamperage) directly increases the efficiency of the treatment and is of special importance when a long target skin distance is used.

All of the foregoing factors combine to increase the tolerable skin dose and the depth dose in the region of the tumor although at the expense of greatly prolonging the individual treatments and multiplying the number of necessary sittings in each case. Insufficient irradiation is worse than none. Biologic researches have shown the dose in roentgens necessary for definite reddening of the skin (erythema dose), this amount varying according to the wave length and the filter employed and physical means are or should be now available in every hospital and radiological institute for measuring in roentgens the output of all therapeutic x ray apparatus.\* As many as four or five tissue doses should be given for most malignant lesions either as a preoperative or as a postoperative measure.

This total dose should be administered in fractions within the shortest time compatible with the patient's reasonable comfort and powers of resistance otherwise an even

\* The international roentgen is that quantity of x ray radiation which when the secondary electrons are fully utilized and the wall effect of the chamber is avoided produces in 1 cc. of atmospheric air at 0° C. and 760 mm. of mercury pressure such a degree of conductivity that one electrostatic unit of charge is measured at saturation current. This unit is designated by small r.

greater amount of treatment will be needed. The aim of the fractionated method should be to reach saturation as quickly as possible by large initial frequently repeated treatments and then by smaller doses daily or on alternate days in order to maintain the radiation effect at a maximum for at least thirty days. The direct effect of the x rays is to damage the cells so badly that mitosis is inhibited. Indirect effects include inhibition of the gaseous exchange resulting from the clotting of blood in the vessels shortly after radiation and some immunizing effect brought about by the dying growth. An inoculated tumor tends to avoid growing into an area of tissue which has previously been irradiated. The embryonal type of cell is more radiosensitive than adult forms. The shorter the life cycle of a cell the more sensitive it is to radiation. Lymphocytes are most sensitive and bone and nerve tissues are most resistant. Other important factors influencing the result of radiation therapy include the general condition of the patient and his ability to react to radiation, the nature of the tumor and the proximity of the growth to important normal tissues that may suffer injury. Increased benefits from the fractionated dose method lie in the improvement in the ratio between the destructive effect on the neoplasm and the favorable reaction on the surrounding normal tissue.

The methods of radium therapy have also undergone considerable modification in recent years. Gold and platinum seeds have been substituted for glass seeds in the direct application of radon (the gas of radium) into the tissues. Great care must be exercised in introducing such seeds or needles to secure a uniform distribution in the area under treatment. There is a rapidly growing tendency to use radium as in external application at a distance of 10 cm. or more from the skin reserving the direct applications for cavities sinuses and interstitial implantation but the distant application of radium through the working of the inverse square law requires such enormous amounts of radium and such long applications that the method is really not very practicable for the treatment of a large number of patients. Certainly it is not economical. Highly filtered x rays produced at high voltage applied with great intensity from a rather

long target skin distance constitute a serious rival to the external application of radium by radium picks even though they contain enormous quantities of radium.

The results of radiation therapy depend on the application and thoroughness of the planning and administration of treatment in each individual case. Even cases utterly hopeless from the standpoint of surgical treatment sometimes yield good palliative results and five year survivals. Some seemingly inoperable cases become operable. Some conditions formerly treated only surgically are now often referred to the radiation therapist especially cancer of the uterine cervix many types of skin cancer and cancer of the lip tongue and pharynx. (See section on Carcinoma of the Lip Tongue and Pharynx.) In others the question of operability is being more closely studied and in some cases surgical removal of the primary lesion and regional glands has been replaced by irradiation treatment of the primary growth and of the regional nodes with perhaps surgical removal of such regional nodes after treatment.

Biopsy is necessary in a great many lesions. It is believed that biopsy should as a rule be postponed until at least two weeks after beginning roentgen irradiation. Lymphatic drainage should be treated first.

Statistics from the leading tumor clinics of Sweden Belgium France England and America have shown that cancer of the breast gives at least double the number of five year survivals if in all cases the operation is supplemented by adequate radiation therapy preferably preoperative. As a preoperative measure at least 5000 roentgens should be applied through three or four areas over a period of twenty one days as the initial treatment in a case of operable cancer of the breast. If the tumor is operable at least three weeks should intervene after the x ray treatment is finished before operation. An interval of from six to eight weeks is better. Attenuation of the cancerous cells and the sealing of blood vessels and lymph channels limits the dissemination of the disease at the time of operation. Preoperative irradiation in cancer of the breast as a routine measure constitutes the greatest advance in the treatment of this disease. Whether or not postoperative treatment is also to be



given depends on the needs in the individual case. Now that the more rational method of preoperative irradiation is coming into recognition there will be some question as to the technic and necessity for additional irradiation after operation if the preoperative treatment has been given to the point of maximum tolerance. If for any reason adequate presurgical x-ray therapy has not been given the lack should be made up after operation. (See section on Carcinoma of the Breast.)

There are of course cases of cancer in which cure can rarely be expected but in which the palliative results are well worth while as in cancer of the urinary bladder malignant lesions of the kidneys and metastatic malignant lesions of bone.

In primary malignant tumors of bone roentgen therapy accomplishes very little except as a palliative and anodyne. Ewing's endothelioma of bone and multiple myeloma are fairly radiosensitive but are difficult to cure because of the diverse distribution of the lesions or distant metastases. Bronchogenic carcinoma and carcinoma of the esophagus stomach colon liver and pancreas are lesions in which therapeutic irradiation has accomplished little. Early diagnosis and treatment are highly important nevertheless less cases which are hopeless for surgical treatment are occasionally benefited by irradiation.

Many lesions of benign character respond to radiation therapy such as tuberculous glands of the neck abdominal tuberculosis and some cases of joint tuberculosis interstitial fibroid tumors when not larger than a three or four months pregnancy and metrorrhagic hemorrhages. Toxic adenomas when not too large usually respond well but the treatments must be continued over a period of three to five months all the doses being suberythema and with adequate filtration. Furuncles carbuncles cellulitis and erysipelas respond promptly to minimal doses. Recently the employment of x-ray in small doses in the therapy of gas gangrene has appeared very promising. Buerger's disease and Raynaud's disease respond nicely to roentgen therapy over the lumbar symp-

thetic system often averting the need of amputation. The only worthwhile treatment for leukemia is roentgen therapy which is also useful in erythremia Hodgkin's disease and lymphoblastomas of any type.

Roentgen and radium rays penetrate the tissues to a greater or less degree and produce ionization within the tissues. Their efficiency as therapeutic agents depends upon this ionization. The development of the cyclotron has made possible the preparation of radioactive phosphorus strontium and other elements. Radioactive phosphorus gives off only beta rays which are easily absorbed. This substance localizes in bone and bone marrow and to a considerable degree in the spleen lymph nodes and liver. Radioactive strontium and calcium localize more or less exclusively in bone. The employment of these radioactive elements in the treatment of surgical lesions particularly cancer is as yet in the experimental stage. The results thus far seem to indicate an effect as good as that obtained with roentgen irradiation in prolonging life with some degree of comfort. There seems to be less tendency to irradiation sickness and other reactions. Four elements or compounds—radioactive strontium phosphorus and iodine and chromic radiophosphate are now being used in therapeutic work.

No attempt has been made in the foregoing to cover adequately the field of roentgen therapy but rather to arouse the physician's natural investigative instinct to look at more length into the possibilities of this rapidly developing method of attacking certain diseases.

JAMES T. CASE

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touch the wound edges with his gloved fingers. He must learn to turn his head away from the field of operation when coughing or sneezing. If he sees a break in technic he must call attention to it.

The student's first duty as a participant in an operation will be retraction. Let him learn at once the art of gentleness, one of the most important principles in aseptic surgery. Every surgeon knows that try as he may the field of operation is never always completely sterile. If tissues are bruised by rough handling they are all the more sensitive to infection from pathogenic organisms.



Fig. 743.—Packing of drum with linen for sterilization in the autoclave.

Granted that the student has a good understanding of bacteriology, he must realize that everything and every one that comes in contact with the patient is potentially a source of infection. The patient himself is a potential source. Among the common organisms that cause wound infection are the streptococcus, staphylococcus and colon bacillus; the streptococcus usually causing the most severe infections.

First consider the patient. Organisms are ever present on the skin in the hair follicles and sebaceous gland—therefore the importance of shaving the operative region and cleansing it with soap and water previous to operation. The operator, his assistants and the nurses are sources of infection and they

must protect themselves against infecting the patient. All materials, linen, sutures, solutions and instruments that come in contact with the patient must be made sterile. The operating room itself must be clean. It is essential to learn how all these requirements can be met.

**Operating Room.**—All modern operating rooms are well ventilated and screened. They should be situated on the upper floors of the hospital, well away from the general activity. The room itself must not be too large, about 20 by 30 feet. It must contain the minimum amount of furniture and apparatus, thus lessening the amount of contaminated surface. If possible, clean operations should not follow dirty operations—other rooms being used for dirty cases. All visitors must be gowned and masked unless they watch from a screened gallery.

**Sterilization of Linen (Fig. 744).**—All gowns, caps, masks, sheets, sponges, towels and dressings are packed in drums. These are heated in the autoclave (Fig. 744) which employs live steam under a pressure of 15 pounds for forty-five minutes. This raises the temperature to 121° C. The drums must not be packed too tightly, or the heat will not penetrate. Cultures should be taken by the bacteriologist of the various sterile drums at frequent intervals.

Rubber gloves are carefully washed and boiled after an operation. They are then dried, examined for holes and resterilized in the autoclave at a pressure of 15 pounds for fifteen minutes on two consecutive days. More prolonged heating would destroy the rubber.

**Water.**—Sterile water is obtained by boiling previously filtered water in a high pressure water sterilizer at a pressure of 15 pounds at a temperature of 121° C. for one hour—one boiler of hot water and one of cold.

**Solutions,** such as saline, glucose and boric acid are placed in flasks and autoclaved at a pressure of 20 pounds for one hour at a temperature of 126° C.

**Rubber tubing,** clysis and infusion sets, suction tubes, drains and flasks of novocain are sterilized in the autoclave at a pressure of 20 pounds for twenty minutes.

**Instruments** are thoroughly washed after an operation to remove blood and other or

gamic matter. They must be of simple construction to make for easy cleansing. They are placed in trays and boiled for from fifteen to twenty minutes. The temperature is  $100^{\circ}\text{C}$ . A 1 per cent solution of sodium carbonate raises the boiling point about  $5^{\circ}$  prevents rust and removes grease. Knife blades are dulled by prolonged boiling and must be treated differently. They are boiled for three minutes and then placed in 70 per cent by weight ethyl alcohol for twenty minutes.

Basins are boiled in a special sterilizer for one hour because they are packed closely.

Suture material in glass tubes comes from the manufacturer already rendered sterile by a special technic. These tubes are stored in 5 per cent carbolic acid solution

however non absorbable sutures may produce slowly healing foreign body sinuses. The finest possible non absorbable interrupted sutures are recommended for all wounds except those infected or potentially infected.

**Setting Up a Sterile Operating Room.**—The nurse with all the materials to be used now sterilized proceeds to set up the room. She first puts on her head protector and mask and then proceeds to scrub and gown as described later. The first step is draping the tables after removing the sheets from the sterile drums (Fig 745). Instruments are then brought in by tray from the adjacent sterilizing room (Fig 746). Basins are set up and filled with sterile water by the unsterile nurse. This same nurse will on

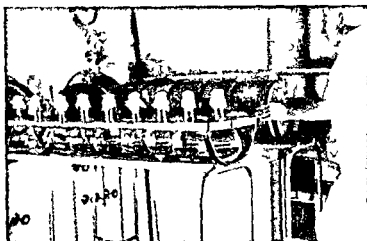


Fig 745—Drums and solution racks preparator to sterilization in the autoclave

and then placed in 70 per cent alcohol for twenty minutes just prior to operation.

Suture material may be of two kinds absorbable and catgut and non absorbable and silk, silkworm gut, horse hair, linen and a fine stainless steel wire. Many surgeons use only catgut for buried sutures. Owing to the continued efforts of Melency, the absolute sterility of catgut is now supervised by the government. The many criticisms of catgut are in regard to its variable absorbability, the deleterious effects of chemicals with production of serum and delayed wound healing and the increased incidence of wound infection, dehiscence and postoperative hernia. Many surgeons advocate the use of non absorbable suture materials for buried sutures usually silk. In the presence of infec-

tion however non absorbable sutures may produce slowly healing foreign body sinuses. The small instrument tray is prepared. Knife blades and tubes of catgut are removed from the alcohol. Suture tubes are broken and catgut is placed in readiness. Sheets for draping the patient are obtained from the drums and the antiseptic solutions for painting the operative site are made ready.

**Masking.**—The surgeon also each assistant after donning a clean white coat, trousers and cap puts on a mask which covers the mouth and particularly the nose. This latter is important for any member of an operating room staff, nurse or doctor may be a carrier of virulent streptococci. No member of an operating team, whether doctor or nurse, should enter the operating

room if he has a cold or sore throat. It is well especially in the winter months to have nose and throat cultures taken frequently of those participating in operations.



Fig. 74—Sterile nurse removes linen from the sterile drums preparatory to draping the instrument tables.

**Scrubbing (Figs 747 to 750)**—The care of the surgeon's hands is most important. Nails must be pared, cuticle clipped and the skin kept soft. No surgeon with an infection



Fig. 76—Removing instrument is from the sterilizer. The hot and cold water sterilizer is in the background.

of his hands or fingers should operate. Prior to operation the tips of the fingers are placed in half strength (3.5 per cent) tincture of iodine and allowed to dry. The fin-

gers, hand and forearms up to and including the elbows are then scrubbed under hot running water with green soap and a good



Fig. 747—Draping the instrument in half strength (3.5 per cent) iodine preparatory to scrubbing up. Note the surgeon's coat, trousers, cap and mask covering the nose.

stiff brush for at least five minutes. The hands are then raised and the water is allowed to drip off the elbows. The hands and



Fig. 748—Scrubbing the hands and arms up to and above the elbows for five minutes.

forearms are then placed in 70 per cent alcohol which is also allowed to drain off at the elbows.

**Gown and Gloves**—The hands are then dried with a sterile towel (Fig 751) The gown is put on (Fig 752) and the hands



Fig 749—All wing water to drain off the elbows

are carefully powdered with sterile talcum Figure 753 shows the proper method of putting on gloves care being taken not to



Fig 750—Rising in 70 per cent alcohol

touch the outer part of the glove with the bare hand While waiting for the start of the operation the surgeon must keep his hands above his waist If the wait is long they should be covered with a sterile towel

**Antiseptics**—So far only sterilization by heat has been discussed It is obviously impossible to utilize this method of obtaining asepsis in connection with the skin of the patient or the skin of the surgeons and nurses Half strength (3.5 per cent) tincture of io



Fig 751—Drying hands with a sterile towel The table holds gowns, gloves and sterile powder can

dine has been found to be satisfactory in preparing the operative site It is put on when the skin is dry, otherwise it will not penetrate It is most important that it be allowed to dry and then removed with 70 per cent alcohol (Fig 754)



Fig 752—Nurse tying up the surgeon's gown

Alcohol 70 per cent is used to finish the sterilization of tubes of catgut and knife blades

Bichloride of mercury in 1:5000 solution is used for washing the gloved hands during

the operation. This should be removed by rinsing in sterile water.



Fig. 753—The proper way for the surgeon to put on his gloves.

Carbolic acid (5 per cent) is used for cauterizing the appendix stump or the cut ends

in surgery but these are perhaps the most valuable.

*Draping the Patient.*—After the site of operation has been prepared with iodine and alcohol if for a laparotomy a small towel is placed just above the pulses and fastened to the skin with two towel clips. Two large sheets are then draped, one over the foot of the table reaching up to the lower margin of the operative field and the other over the head of the table reaching down to the upper margin of the field and draped over the ether screen. Four towels are then affixed at right angles to one another leaving room for the skin incision (Fig. 755). Finally a large sheet with a central opening is placed over the entire table. The small instrument tray is brought over the foot of the table and adjusted to the proper height. The surgeon, his assistants and the nurses then take their proper positions and the incision is made (Fig. 756).

The sterile field must be made as small as possible in order to avoid 'unsterilizing'. The assistants must keep their hands in the field; they must not reach for instruments behind the operator (Fig. 757).

Any instrument which partially slips off the table is unsterile and must not be touched. Any break in the sterile technic must be immediately reported though it means the setting up of an entire new sterile operating room rather than run the



Fig. 754—Iodine (10a strength) being squeezed into the umbilicus preparatory to painting the abdomen. The patient is to undergo an appendectomy under spinal anesthesia.

of other hollow intra-abdominal organs. Carbolic acid (3 per cent) is used to store tubes of catgut. Many other antiseptics are used

risk of having a severe infection develop in the patient and possibly cause his death.

In spite of all the many safeguards that



Fig. 755—Draping the patient. Only the operative area is exposed



Fig. 756—The incision. Showing the position of the various members of the operating team. The surgeon with his second assistant to the left, his first assistant across the table, the sterile nurse handing an artery clamp, the anesthetist at the patient's head.



Fig. 757.—An improper way of handing instruments—behind the operator.

have been discussed there are still weak links in the chain of aseptic surgical technic. Melenev<sup>3</sup> in 1935 in a study of the bacterial flora in his operating room estimated that from 35 000 to 60 000 bacteria fall on the operative field during the course of an hour. In other words every wound under usual operating room conditions is contaminated. Fortunately few wounds become infected probably because of the natural resistance of tissues and the fact that different individuals vary in their susceptibility to infection. Nevertheless the average incidence of infected wounds today is from 4 to 6 per cent sometimes rising as high as 20 per cent.

How can the number of air borne bacteria in an operating room be reduced? A number of procedures have been proposed to reduce infection of clean surgical wounds to an irreducible minimum. One must mention particularly the work of Hart<sup>4</sup> who proposed the destruction of air borne bacteria in an operating room by bactericidal radiant energy through continuous special ultraviolet radiation of the air and the field of operation. His work is most encouraging. The use of proper masks for the operating room personnel is obvious. However the perfect mask which absolutely prevents the outflow of bacteria from the nose and throat has not been found. Most masks used today by sur-

geons deflect bacteria from the operative field rather than filter them from the expired air. Arnold<sup>5</sup> believes that cellulose wadding is the best material for filtering the expired air. It is far better than the cotton gauze commonly used. De Takats<sup>6</sup> suggests the use of a flannel mask which he claims successfully filters the expired air. Sturge Davis<sup>7</sup> suggests the use of two masks covering both mouth and nose each consisting of three to four thicknesses of woven muslin 60 to 65 strands to the square inch.

Jackson<sup>8</sup> believes that mechanical cleansing with soap and water just before the closure of a clean surgical wound is not harmful to good wound healing and will prevent the small percentage of infections that still remain as a plague in every surgical clinic.

COMMANDER CARLES WEEKS

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## XXXIX. MINOR SURGICAL PROCEDURES

**Hypodermoclysis**—Hypodermoclysis is the term applied to the subcutaneous infusion of large amounts of fluids. Favorite sites for hypodermoclysis are the loose subcutaneous articular tissues of the thighs and low in the axillae or flanks and the submammary connective tissue. For infants the subcutaneous tissue of the back or buttocks may be preferable. Following prolonged inhalation anesthesia it is not advisable to give submammary infusions because of the danger of further embarrassing the respiration and thus predisposing to pulmonary complications. The apparatus most commonly used consists of two long needles (3 or 3½ in.) connected by means of a glass Y and rubber tubing with a sterile container which is suspended approximately 2 feet above the level of the patient. The rate of flow is controlled by a clamp on the tubing just below the bottle and by using needles of small caliber (18 or 20 gauge), overdistention of the tissues should be avoided so as not to cause the patient any unnecessary discomfort. Woodyatt<sup>1</sup> advocates the use of several small needles in order to accelerate the rate of absorption and to prevent undue distention of the tissues, these are connected with the central apparatus by means of rubber tubes and a Carrel-Dakin glass connecting piece. Solutions must be carefully prepared; the ones most commonly employed are normal saline and 5 per cent dextrose Ringer's solution. The rate of flow should not be greater than 500 cc per hour when multiple needles are used the amount can be increased proportionately.

**Intravenous Infusion (Venoclysis)**—Intravenous infusion implies the introduction of large quantities of fluid into a vein. A No. 19 or 20 gauge needle is inserted into any suitable superficial vein. Difficult veins may necessitate the use of a cannula after cutting down on the vessel; in this event the vein should be isolated from its bed and two catgut ligatures thrown around it the distal one tied and the proximal one left loose until the infusion has been completed. After the

distal ligature has been tied the vein is partially incised transversely with sharp pointed scissors and the cannula slipped into its lumen through the incision. With moderate skill and a sharp needle it seldom should be necessary to cut down on a vein. In intravenous work more failures are due to a dull needle than to any other single factor. Once the needle or cannula is properly placed in the lumen of the vein it is connected with a piece of rubber tubing (all air having been expelled from the tubing by allowing the solution to run through it) which leads to a buret or volumeter flask supported near the bed (Fig. 758). The rate of flow is regulated by the height of the flask above the vein and by a clamp on the rubber tubing. The drip chamber shown in figure 58 provides an excellent indicator for regulating the rate of flow. Woodyatt recommends that the rate of flow be determined by the body weight: 1 cc per minute for a patient weighing from 100 to 150 pounds and 5 cc per minute for a patient weighing from 150 to 200 pounds. This is of especial importance when dextrose solution is being used as the patient can absorb only 0.8 Gm. of glucose per kilogram of body weight per hour. Glucose given in quantities exceeding this amount acts as a diuretic and a dihydrant. Solutions which may be used for venoclysis are normal sodium chloride 5 to 20 per cent dextrose solution (5 per cent dextrose is most nearly isotonic with blood), gum acacia, Hartmann's solution, plasma, blood serum and compatible whole blood. All solutions for intravenous use should be prepared with extreme care so that no reactions will be caused by them. Only fresh solutions should be used and these must be bacteriologically and chemically pure. Certain of the commercial laboratories have prepared solutions for intravenous and subcutaneous use which are put up in sealed glass containers thus making this form of therapy available to the general practitioner.

**Blood Transfusion**—The technique of blood transfusion has been so greatly simplified

fied in recent years that its use is now available to physicians everywhere. Formerly it was a hospital procedure but now blood can be readily given in the home on the battle field or on ships at sea.

*Selection of the donor* is of prime importance. Syphilis in the donor must be carefully excluded both by history and by the Wassermann test. A recent attack of typhoid fever, diphtheria, malaria, influenza, tuberculosis or rheumatism should disqualify a prospective donor. The blood of the donor

Group II (A—Landsteiner) —Serum agglutinates corpuscles of groups I and III. Corpuscles are agglutinated by sera of groups III and IV (Approximately 40 per cent of all persons belong in group II).

Group III (B—Landsteiner) —Serum agglutinates corpuscles of groups I and II. Corpuscles are agglutinated by sera of groups II and IV (Approximately 7 per cent of all persons belong in group III).

Group IV (O—Landsteiner) —Serum agglutinates corpuscles of all other groups.

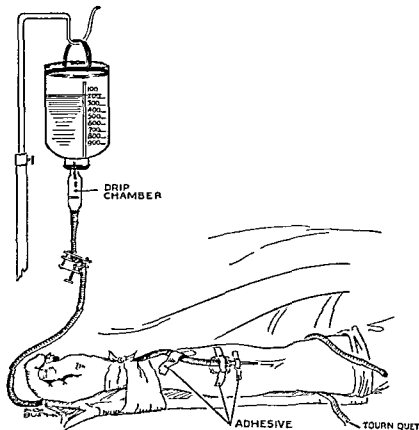


Fig. 58.—Illustration of fluid (A special type of drip chamber containing a filter is used for blood).

should be typed and if it is found to be in the same group as that of the recipient the bloods of the two should be cross typed. Failure of agglutination with the cross typing indicates compatibility of the two bloods.

*Blood Grouping* —Moss<sup>3</sup> found that all bloods could be classified into four groups according to their agglutination reactions.

Group I (AB—Landsteiner) —Serum does not agglutinate the corpuscles of any group. Corpuscles are agglutinated by sera of groups II, III and IV (Approximately 10 per cent of all persons belong to group I).

Corpuscles are agglutinated by none of the sera (Approximately 43 per cent of all persons belong in group IV).

For Lee's technique of blood grouping there should be kept on hand fresh sera of persons belonging to groups II and III.\* To carry out the tests a suspension of the donor's red cells is prepared by placing two or three drops of his blood into 1 cc of citrated salt solution. A platinum loopful of standard group II serum is deposited on a slide and

\* Stock sera obtained from one of the local laboratories are recommended for general usage.

in it is emulsified a loopful of the donor's red cell suspension. The agglutination can be observed with a low power magnifying glass. Agglutination when it occurs is complete in from five to fifteen minutes. The test is repeated with group III serum (this may be done simultaneously for expediency). If both sera agglutinate the donor's cells he belongs to group I. If neither agglutinates them he belongs to group IV. If agglutination occurs with group II serum and not with group III the donor belongs to group III. Agglutination by group III serum but not with group II puts him in group II.

Cross typing is done by mixing a loopful of the donor's cells with a drop of the recipient's serum. If agglutination occurs the donor should be rejected even though he belongs to the same group as the recipient. Guthrie and Huck have demonstrated the existence of subgroups which the usually employed methods of blood grouping fail to detect.

In an emergency it may be necessary to dispense with the time consuming procedure of grouping the bloods. In such instances compatibility can be directly and quickly determined by cross typing. It is advisable if expediency permits to select a known group IV donor. However the cross matching never should be omitted.

*Methods of blood transfusion in most common use today are the indirect or citrate method of Lewisohn<sup>4</sup> and the direct methods of Landmann, Kimpton, Brown, Unger and Scannell.*

*Citrate Method*—This method is the one most widely used today. The procedure as described originally by Lewisohn has been variously modified but its essential features are unchanged: there are (1) collection of the blood from the donor, (2) addition of sodium citrate (10 cc. of a 2.5 per cent solution for each 100 cc. of blood) and (3) introduction of the citrated blood into the recipient's vein (Fig. 758). The use of a sealed flask for collecting the blood represents the most significant improvement over the original technique. For the procedure as carried out by our transfusion team the following materials are required: (1) two needles of sufficiently large gauge to insure free passage of blood through the lumen (a No. 15 or 16 gauge needle is recommended for the donor's

vein and a No. 19 or 20 gauge for the recipient's); they must be sharp and should possess a short bevel. (2) a vacoliter flask fitted with a rubber stopper and containing 70 cc. of 2.5 per cent solution of sodium citrate in normal saline solution. (3) a second piece of rubber tubing (15 to 18 inches long) fitted with an adaptor at one end and the special valve with attached needle at the other (Fig. 759 B), (4) a hypodermic syringe containing a 1 per cent solution of novocain and (5) an ordinary vacoliter type of intravenous set. The apparatus is assembled as shown in figure 759 and the blood flow from the donor's vein is regulated by means of the valve. The negative pressure in the sealed flask insures a steady flow.

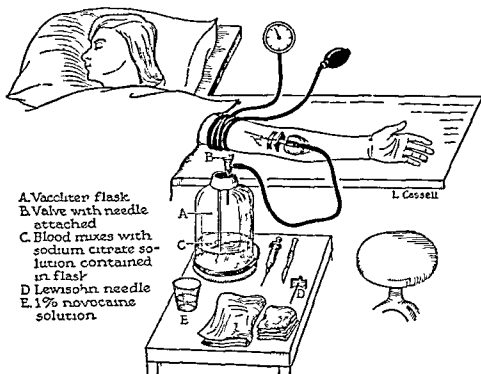
A blood pressure cuff is placed on the donor's arm to serve as a tourniquet and the arm is prepared as for any intravenous infusion. Prior to insertion of the needle a drop of 1 per cent novocain shall be injected intradermally over the vein selected. Dodd says: "This anesthetic is not a courtesy to donors; it is a right." The needle is then inserted into a large vein, preferably directed peripherally. The rate of the flow of blood from the donor is regulated by the valve mechanism. As the blood flows into the flask it is agitated gently to insure mixing with the citrate. Violent agitation should be condemned because of the danger of destroying the platelets and cellular elements. Use of this technique makes certain that the blood is at no time exposed to the air. When the desired amount has been obtained the needle in the donor's vein is withdrawn and the valve with its attached needle is removed from the rubber stopper in the vacoliter flask. The flask is then transported to the patient's room; the rubber disk which seals the air vent and the hole for the attachment of the tubing of the recipient set is torn away from the stopper and the flask is substituted for the flask in the intravenous set which is in operation at the recipient's bedside (Fig. 758). A metal filter set is attached below the flask containing the blood. The infusion should be given slowly (forty minutes to an hour being allowed for 500 cc. of blood) and measures adopted to prevent the blood from becoming chilled before it enters the recipient's circulation; this is accomplished by immersing the rubber tubing

of the intravenous set in a basin of water maintained at slightly above body temperature.

The donor's arm should be carefully bandaged following the withdrawal of the needle in order to prevent the development of a hematoma or secondary infection. He should be instructed to remove the bandage in from twelve to twenty-four hours.

The advantages of the citrate method are several. (1) It is simple and applicable for

effect. However, it has been shown that temporarily the coagulation time of blood actually is decreased following the injection of citrated blood. A more plausible objection is that of the destructive action of the drug on the complement, thus reducing its phagocytic and opsonic powers. The latter contraindicates its use in cases of sepsis or in the presence of general infections. Administration of heparin to the donor just prior to transfusion has been proposed. In this way



- A. Vacoliter flask
- B. Valve with needle attached
- C. Blood mixes with sodium citrate solution contained in flask
- D. Lewisohn needle
- E. 1% novocaine solution

Fig. 39—Commercial vacoliter flasks such as the one shown in this illustration have greatly simplified the withdrawal of blood from a donor. The rubber stopper is covered with a airtight rubber disk to preserve the vacuum. The special needle which is attached to the valve mechanism is passed through this rubber disk after being connected with the rubber tubing. After the needle is inserted into the donor's arm, the valve is carefully opened and regulated so as to produce a brisk, steady flow of blood. When the desired amount of blood has been taken, the valve needle is withdrawn, the airtight rubber disk is peeled off, and the tube to the recipient (which contains the metal filter) is connected with the flask by the insertion of a glass tube into the rubber stopper. The flask is then inverted and suspended from a stand at a height to insure flow by gravity.

use by the general practitioner and (2) it permits transportation of blood before use. (3) avoids all possibility of infecting the donor. (4) minimizes the danger of clotting, and (5) requires no assistants. The disadvantage most commonly mentioned in connection with this method is that the blood is altered by the addition of an anticoagulant. Sodium citrate has a tendency to destroy blood platelets and this would seem to contraindicate its use for hemostatic

the clotting time of the donor's blood can be prolonged sufficiently to obviate the necessity for using sodium citrate. However, heparinized blood should not be given when hemostasis is of concern.

**Blood Transfusions in Infants**—For infants, transfusion requires the utmost precision and should not be undertaken by one unskilled in intravenous technique. The great saphenous vein just anterior to the medial malleolus and the small saphenous vein just

posterior to the external malleolus are the veins of choice because of their relatively large caliber and the better chance of immobilization of the part. The latter can be accomplished by placing a small wooden splint along the outer aspect of the leg opposite the operative field and fixing it in place with adhesive strips. The foot should be strapped to the splint in the position of plantar flexion if the great saphenous is to be used. A preliminary intradermal injection of novocain is advisable in order to minimize subsequent struggling on the part of the infant. With a lancet pointed scalpel a small incision (1 cm.) is made in the skin overlying the vein and the latter elevated into view with the aid of a small fine pointed tissue forceps thus being used as a skid rather than to grasp the vein. Once exposed the vessel is opened with a delicate fine pointed scissors and a No. 19 gauge needle with a 45 degree bevel inserted. The needle can be held in place with an 00 catgut suture or better by clamping it just above the opening in the vein with a specially constructed mosquito forceps through the blades of which near the tip a hole has been drilled which is just large enough to clasp a 19 gauge needle. Citrated blood is then injected. Gentle pressure will control leakage of blood from the vein following with drawal of the needle thus preserving the vein for future use.

**Refrigerated Blood.**—Citrated blood may be preserved in a refrigerator at 4° C. for as long as two weeks without serious deterioration. Studies by Bull and Drew<sup>2</sup> revealed as the outstanding changes in refrigerated blood a loss of white cells and platelets an increase in plasma potassium and a decrease in prothrombin. However for most clinical purposes it should give the same results as fresh blood. Transitory jaundice has been observed in recipients given preserved blood which has been stored for nine or more days. Because of this limited period of usefulness it is probable that refrigerated whole blood will give way to the use of plasma which is becoming recognized as an excellent substitute for whole blood and can be stored for a much longer time.

**Direct Method.**—The Sennell apparatus consists of a three-way stopcock with rubber tubing and adaptors for each of the three

fittings two cannula type needles and several 25 cc. special Iuer syringes.

In former years the direct method of blood transfusion was widely used but with the increase in popularity of the citrate method it has become almost obsolete.

Advocates of the direct method of transfusing blood claim for it the advantages of (1) the use of unmodified blood (2) less chance of contamination (3) no disturbance to the platelets and (4) less chilling of the blood.

The disadvantages of this method are that (1) special apparatus is required (2) the donor and recipient must be in the same room with consequent psychic trauma to the patient and (3) if blood clots in the apparatus this may be difficult of correction.

**Reactions.**—It is doubtful if the method employed *per se* has any influence on the incidence of reactions following transfusions. Studies conducted by Lawsohn<sup>3</sup> and Lund<sup>4</sup> lend conviction to the conclusion that post transfusion chills with an elevation of the temperature are due to (1) improper heating and sterilization of the material used (2) imperfect technique of transfusion or (3) incompatibility of the donor's blood with that of the recipient.

**Plasma Transfusion.**—In recent years the therapeutic value of human plasma and serum as a substitute for whole blood has been definitely established and its numerous advantages are being demonstrated daily in the present world war. The problem of surgical shock long has occupied the attention of medical investigators and numerous theories have been advanced to explain this physiologic phenomenon (See section on Shock). The principal advantages of plasma or serum over whole blood are that it can be safely stored for long periods and that it does not require typing before infusion. Plasma may be prepared from fresh citrated or heparinized blood or from stored or preserved whole blood. The cells may be separated either by centrifugation or by sedimentation. The former is the practice in large hospitals or where large amounts of plasma are needed and is accomplished by use of large centrifuge flasks. It has the advantages of speed and elimination of hemolysis. Regardless of the method used in

separating the cells, the plasma is aspirated aseptically and, after testing for pyrogens and sterility, is stored at room temperature,

Plasma may also be dehydrated and stored in the dried state, but this is a complex, costly and difficult procedure. Dried plasma,

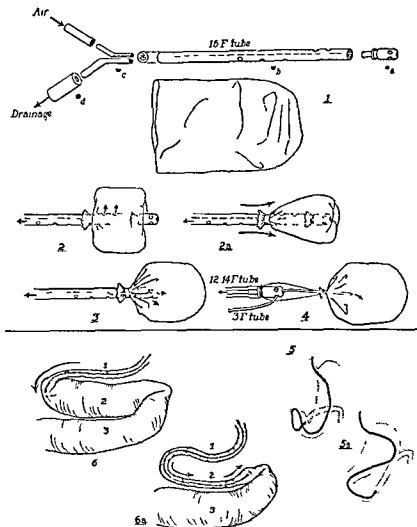


Fig. 760—Technic of intubation. 1 the component parts of a tube for the small intestines. a, The aspirating tip size 16 F, b, double-lumen tube with perforations from the small lumen for inflation of the balloon and into the large lumen for aspiration of intestinal contents. c, metal connections. d, round rubber tubing connecting the apparatus to aspirating bottles or to a syringe for the injection of air (the rubber balloon is cut to the correct size before being tied on the tube). It is of great importance in assembling a tube to safeguard against blockage by seeing that the diameter of the lumen of every part from tip to bottle increases progressively. 2, the tube assembled for aspiration both ahead of and behind the balloon. In 2a is shown the importance of a loose balloon that can sag forward temporarily covering the tip as it advances. 3, the tip is mounted on the small lumen so that the balloon precedes the tube, an assembly that is particularly useful in the presence of multiple adhesions. 4, the balloon on a separate tube draws a single-lumen aspirating tube after it, a device used chiefly in cases of multiple partial obstructions. 5 and 5a, the fluoroscopic appearance of tubes at the point in the duodenum at which the balloon may safely be inflated without fear of its being regurgitated back into the stomach. 6 and 6a, the way in which a tube is believed to empty the intestine segment by segment, deflating it, allowing the blood supply to return and then being advanced to the next point of angulation by the returning peristalsis.\*

at 4° C. or is frozen. Freezing is the best procedure, as no bacterial growth and no precipitation of fibrin occur at this temperature. Frozen plasma will keep indefinitely.

however, has the important advantages of reduced bulk and sterility under any conditions of temperature. It can be regener-

\* Abbott Arch. Int. Med. 63

ated in ten to fifteen minutes by the addition of sterile distilled water. For these reasons this type of plasma is used by the Army in the field.

For routine use the most satisfactory method of keeping plasma is in the frozen state. Any mechanical refrigerator will accommodate a few bottles (250 cc of plasma in a 350 cc bottle). For prolonged storage however in icecream cabinet or other below zero unit should be employed. Frozen plasma is melted at 37° C and can be administered within fifteen to twenty minutes after being ordered.

**Proctoclysis (Murphy Drip)**—Rectal infusion represents the simplest method of supplying fluids to the unconscious patient. When well tolerated it can be substituted for parenteral clisters throughout convalescence. It requires no elaborate apparatus or sterile solutions and can be given by any intelligent nurse. Luckhart has shown that of the glucose solutions the 1 per cent concentration is absorbed most rapidly and is least irritating to the colon. *Retention enemata* may be substituted for the Murphy drip to supply fluids postoperatively. For this purpose from 4 to 6 ounces of a 1 per cent solution of glucose is given through a catheter at four hour intervals. Stimulants (whisky brandy coffee etc) and sedatives (bromides chloral etc) may be administered as retention enemata.

**Phlebotomy**—Phlebotomy (venesection) is the term applied to the opening of a vein for blood letting. As a therapeutic measure blood letting no longer enjoys the popularity it once held. However it is a useful procedure in certain forms of hypertension, amenorrhea, polycythæmia vera and congestive heart failure.

**Gastric Lavage**—Washing the stomach is accomplished by passing a stomach tube or nasal catheter (Levin tube) into the stomach. The latter is better tolerated by most patients and since it is less likely to be accompanied by retching is recommended for postoperative aspiration. The catheter should be lubricated with mineral oil and gently introduced through the nares when the pharynx is reached the patient is given a glass of water and a straw and instructed to swallow. The tube can be inserted without difficulty while the patient swallows the

water. After the tube has reached the stomach a syringe is attached and the gastric contents are aspirated.

**Wangensteen Suction Apparatus**—The Wangenstein suction apparatus consists essentially of a water siphonage outfit, a calibrated bottle for measuring aspirated gas and a Levin catheter. If the Wangenstein suction apparatus is used longer than two or three days the danger of esophageal erosion should be kept in mind. (See section on Intestinal Obstruction).

**Intestinal Intubation (Miller Abbott Tube)**—Intubation of the small intestine by means of the Miller Abbott tube has proved to be a valuable diagnostic and therapeutic aid in a variety of intestinal conditions. Decompression of the bowel by this means is particularly effective in paralytic ileus and non-strangulation types of obstruction. The apparatus consists of a three-bottle Wangenstein system and a double-lumen tube with an inflatable rubber balloon at the tip. One of the inner tubes is an aspirating tube the other is a tube for inflating the balloon. The housing tube should be 10 to 12 feet in length with a circumference of 10 mm (Fig 760). The chief obstacle to successful use of the Miller Abbott tube lies in the difficulty so frequently encountered in passing the tip beyond the duodenum. This difficulty is naturally increased in the presence of intestinal obstruction. Abbott<sup>7</sup> says: "In most instances the best results are obtained by using more patience than most men can readily muster in the presence of a critical situation. His description of the technique for passing the tube is as follows:

1. Insert an applicator wrapped with cotton to the diameter of the tube for 3 in. of its length and saturated with 2 per cent pontocaine in the s.d. of the patient's nose which admits it most freely. The tip should abut against the posterior nasopharynx.
2. Test the patency of both tube lumina with a syringe and test the balloon with water for leaks.
3. Inflcate the tube and empty balloon with an oil free jelly.
4. Remove the applicator and pass the tube in through the nose until the tip enters the stomach. As a rule vomiting prevents the patient's disorder has emptied the stomach if not empty it.
5. Place the patient prone with his head to the left, or as nearly in this position as possible.
6. Inject 500 cc of air not into the balloon but into the patient's stomach. Advance the tube to the 75 cm mark in a small patient or to 80 cm in a large one. Connect the suction apparatus

to the tube for the immediate withdrawal of the injected air and the intestinal contents that an obstructed bowel intermittently regurgitates into the stomach. The purpose of this procedure is to distend the stomach enough to allow the tip of the tube to pass from the left to the right hand portion for in the presence of intestinal obstruction the antrum and body of the stomach are in tight contraction and a tube passed without this precaution will coil in the fundus. The tube should be taped to the patient's nose and the patient allowed to remain in this position for an indefinite period until the tip enters the transverse portion of the duodenum. In general the period for which it is safe to wait depends on the state of the patient. In the absence of strangulation the patient will improve hour by hour from the withdrawal of intestinal gas and fluid which finds its way back to the stomach. Intravenous infusions or blood transfusions may be given at this time and fluid by mouth if as much is aspirated as is swallowed. A 0.45 per cent salt solution may be drunk but if this is distasteful 0.6 Gm sodium chloride in capsules should be given for every 100 cc of drainage.<sup>8</sup> The tube cannot be passed further until the balloon has entered the third part of the duodenum or inflating it will cause its regurgitation back into the stomach. Its position may most easily be checked at frequent intervals by applying a dry clean glass 50 cc syringe with a smoothly ground barrel to the balloon lumen and injecting 10 cc of air. With practice it soon becomes possible to recognize the characteristic feel of duodenal contractions as transmitted to the syringe plunger. A more certain method is to take a bedside film aimed at the upper abdomen. Fluoroscopy is the most certain but the most trying procedure to the patient.<sup>9</sup> When in place the balloon should be filled with 25 cc to 30 cc of air but no more and the air passage clamped. It is well to test the balloon occasionally thereafter in case a leak has developed.<sup>10</sup> The attendant nurse should from this time on pass 6 in of the tube into the patient's nose each hour retaping it with tape. If the balloon is pulling the tube out of the stomach as fast as it is being introduced no nausea will accompany this procedure. Should the patient suddenly begin to choke on the tube no more should be passed than goes in without gagging as it is probable that the tip has reached the obstruction and is no longer advancing. The tape should be removed from the patient's nose at this time if the obstruction is mechanical. In a case of paralytic ileus when distention has been relieved the balloon may be emptied. It is then safe to allow the tube to remain taped to the patient's nose indefinitely.<sup>11</sup> From the time the tube reaches a position 3 ft beyond the pylorus food as well as drink should be given in five small feedings daily as tolerated. Since the residue must be aspirated through the tube it is important that a low residue diet be selected. I prefer to begin with the half strength physiologic saline referred to above and to add in the following order: dilute strained fruit juices, clear unseasoned soup, tea, coffee, rice, melba toast, soft cheese, meat or fruit jellies, farinae, lean rare beef and lamb, boiled or baked fish, mashed potato, milk, butter and pureed vegetables. Sugar and salt are used freely and skim milk in tea, coffee and on cereals at any time.<sup>12</sup> If the tube is

to remain in place for more than a few days routine examination of the nose and throat is advisable. If ephedrine or a comparable substance is used routinely in the nose and if the patient is urged to eat little difficulty need be anticipated from mucosal irritation.<sup>13</sup> The tube is removed by emptying the balloon and withdrawing 1 ft every fifteen minutes. If the balloon has been expelled by rectum cut off the tube at the nose and withdraw it at the same rate from below. In an emergency it may be necessary to use a wire stylet and pass the tube with the aid of the fluoroscope.

**Spinal Puncture**—Spinal puncture (rachicentesis) is the introduction of a needle into the subarachnoid space. It is indicated (1) to relieve spinal fluid pressure, (2) for spinal fluid analysis and (3) for spinal anesthesia.

**Technic**—Unless the patient is too ill to be moved he should be placed on a table before spinal puncture is attempted. He is then instructed to lie on his side, clasp the knees with his hands and draw them tightly against the abdomen, flexing the head and shoulders at the same time. This will arch the back and widen the intervertebral spaces. A small pillow or folded sheet is placed under the head for comfort. The shoulders and iliac crests should be perpendicular to the table. Proper attention to these details will facilitate the introduction of the needle into the subdural canal.

Having satisfied himself that the patient is in the correct position the operator should carefully asepticize the skin for a considerable area around the site chosen for the puncture. This is best done by thoroughly scrubbing it with ether and applying two coats of a 2 per cent solution of iodine. Sterile towels draped over the unprepared skin will provide additional protection against contamination. The fourth lumbar interspace is the site usually chosen for spinal puncture. When this space has been located by approximating the center of a line connecting the two iliac crests it is carefully palpated with the thumb of the left hand and the overlying skin anesthetized with a 2 per cent solution of novocain.

The spinal puncture needle should be of strong yet flexible material. A short bevel with a sharp cutting edge will minimize the danger of injury to the nerve filaments of the cauda. A 20 gauge needle is best for diagnostic puncture and drainage, while a smaller needle (22 gauge) is recommended



for use in spinal anesthesia. In performing the puncture the shaft of the needle is steadied with the first three fingers of each hand, the thumbs controlling the base and inserted in the midline through the middle of the interspace with the shaft perpendicular to the skin surface (Fig 761). Resistance will be felt when the interspinous ligament is reached and again when the needle point comes in contact with the dura. There is a sudden release when the dura is punctured. The stylet is then withdrawn and the spinal fluid collected in sterile test tubes. A free flow indicates a satisfactory puncture; if the flow should stop it usually can be reestablished by rotating the needle 90 degrees, care being taken not to change its position otherwise unless the stylet is rein-

serted and roentgenologic examination. If the scapula interferes it may be moved forward and laterally by having the patient place the hand that corresponds to the affected side on the tip of the opposite shoulder. Appropriate drapes of sterile towels should then be applied.

A small wheal is raised in the middle of the desired interspace by the injection of a small quantity of a 1 per cent solution of novocain. A larger needle should then be used for thorough infiltration of all intercostal tissues as far as and including the pleura. Perforation of the parietal pleura may cause some distress. This can be decreased by slowly injecting the anesthetic substance as the needle proceeds. An additional advantage in slowly introducing the needle is that it

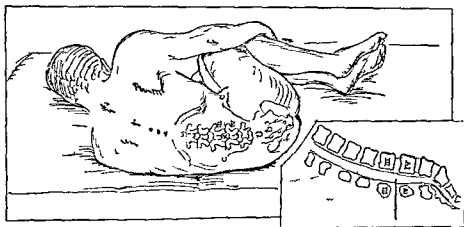


Fig 761—Lateral position for spinal puncture. Site of puncture is at x.

serted. The spinal fluid pressure may be measured by connecting the needle to a manometer.

**Thoracentesis**—Surgical puncture or tapping of the thoracic wall usually is referred to as thoracentesis, although the terms paracentesis thoracis and pleurocentesis frequently are used. Under ordinary circumstances the procedure is simple and may be carried out in the patient's room. If the condition of the patient will permit, however, he should be taken to the operating room and placed in a sitting position. A wide area around the point through which the needle is to be inserted should be well scrubbed with ether and two coats of 2 per cent iodine (or some other recognized antiseptic) should be applied. The point of aspiration can be determined only by per-

cussion obtained as to the situation of the tip of the needle. If injection suddenly becomes easier after slight increased resistance the tip is probably in the pleural space. Withdrawal of the plunger should cause pleural fluid to flow into the syringe. If no fluid is obtained the needle probably was not inserted far enough. If bloody, frothy material is obtained the tip of the needle probably is in pulmonary tissue and should be withdrawn.

The most important point to remember is that the intercostal vessels course along the lower borders of the ribs and that serious hemorrhage may result from injury to these vessels. Pneumothorax may be avoided by meticulous care in the application of

\* Cline's *Minor Surgery*, W. B. Saunders Co., Philadelphia.

syringe or rubber tubing to the needle the tip of which is in the pleural space. A large quantity of air can be drawn into the pleural space during inspiration even through a needle of small gauge. A sufficient quantity of pleural fluid for bacteriologic examination can be obtained with a small syringe. For removal of larger quantities a large bottle from which the air has been exhausted with a vacuum pump will be found to be of great convenience and the possibility of producing pneumothorax is decreased because of the less frequent change of apparatus. A small sterile sponge should be placed over the puncture wound after the needle has been withdrawn.

**Paracentesis Abdominis**—Paracentesis abdominis is indicated in cases in which an excessive quantity of ascitic fluid has accumulated in the peritoneal cavity. With the patient seated in a chair the midline of the abdomen 2 to 4 inches below the umbilicus is the puncture site most commonly chosen as it insures dependent drainage and is an area of abdominal wall which is relatively avascular. The skin is painted with iodine and the puncture site anesthetized by infiltration with 1 per cent novocain solution down to the peritoneum. A small incision is then made in the skin with a lancet pointed scalpel and the trocar carefully pushed through the abdominal wall increased resistance followed by a sense of release indicates that the peritoneal cavity has been entered. Failure to obtain a free flow of fluid usually means that the intestine or omentum is obstructing the open end of the cannula. This can be remedied by reinserting the mandarin and gently rotating the trocar. Too rapid withdrawal of fluid should be avoided because of the danger of syncope. Christopher<sup>8</sup> warns against the danger of perforating the intestine in cases of tuberculous peritonitis and suggests that this condition be ruled out before aspiration is attempted.

**Aspiration of a Hydrocele.**—Aspiration is a palliative procedure for an excessive accumulation of fluid in the tunica vaginalis. An intradermal wheal of novocain at the puncture site will be appreciated by the patient. The scrotum is grasped with the left hand so that the testis which lies posterior to the hydrocele is out of the way. A small

trocar or large hollow needle is then inserted at the anterior dependent portion of the scrotum and directed upward and forward. In cases of moderate distention in which the testis lies in the dependent portion of a large scrotal sac Croft<sup>9</sup> advocates introducing the needle anteriorly at the upper limits of the hydrocele directing its point downward and anterior to the testis.

**Aspiration of a Joint**—Aspiration of a joint may be required to relieve pressure to obtain fluid for bacteriologic study or to irrigate a joint cavity in cases of infection. An aseptic technic should be carefully observed in all instances in which the joint cavity is to be entered. In aspirating the knee joint the needle is inserted 1 inch to the outside of the patella<sup>10</sup> and carried toward the middle of the joint. The point at which the needle is inserted for entering the hip joint is midway between the great trochanter and the intersection of the femoral artery with Poupert's ligament. The shoulder joint is approached from the posterior aspect the needle being inserted just distal to the base of the acromion process between the posterior border of the deltoid and the tendon of the infraspinatus. The needle is directed toward the index finger of the surgeon's free hand which is placed on the coracoid process in front. (A small preliminary skin incision is advised for all cases in which an uninfected joint is to be aspirated.)

**Intubation**—Intubation is the introduction of a hard rubber tube into the larynx for the relief of threatened asphyxiation. It is usually done in cases of laryngeal diphtheria in which the larynx has become so edematous as to interfere with respiration and for asphyxia neonatorum. A sheet is wrapped around the patient's body including the arms and the head is steadied by an assistant. A mouth gag should be inserted to prevent closure of the jaws. The index finger of the operator's left hand is introduced into the pharynx as far as the epiglottis which is lifted up while the tube with its carrier is inserted into the back part of the mouth with the right hand. The tube is carefully directed into the larynx over the operator's left index finger as a guide. The obturator is then withdrawn and the silk thread which is attached to the intubation

tube is anchored by adhesive plaster to the outside of the cheek.

**Peritoneoscopy**—The rapid growth in the popularity of endoscopic procedures has come to include visualization of the peritoneal cavity and its contents. Although its usefulness is somewhat restricted to certain chronic conditions (suspected carcinomatous metastases, cystic tumors, etc.) valuable diagnostic information may be obtained and laparotomy avoided. The endoscope is introduced into the peritoneal cavity through a stab wound in the abdominal wall following the injection of air through a pneumoperitoneum needle. Further distention is carried out by means of an air bulb which is connected with the scope. The peritoneal cavity and its contents then become visible with proper manipulation of the scope.

**Resuscitation**—Cessation of respiratory and circulatory activity following prolonged submergence, carbon monoxide poisoning, electric shock, traumatic shock, operating room accidents and so forth call for prompt and intelligent action.

**Artificial respiration** is the principal aid to resuscitation in cases of drowning, gas poisoning and electric shock. The prone pressure method<sup>11</sup> is advocated for such emergencies. For asphyxia in the operating room, Silvester's method of producing expiration by compressing the sides of the thorax with the patient's arms grasped with the hands of the operator and obtaining inspiration by fully extending the arms to the sides of the patient's head is recommended. In all such instances a finger should

be inserted into the anus for the purpose of dilating the anal sphincter as this maneuver is often followed by a dramatic respiratory response on the part of the patient. Bibcock<sup>1</sup> emphasizes the value of mouth to mouth insufflation in such emergencies. In cases of asphyxia during the induction stage of anesthesia or following high spinal anesthesia the patient's head should be lowered to the Trendelenburg position in addition to the other measures suggested.

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## XL. ANESTHESIA

### GENERAL ANESTHESIA

The administration of anesthesia is an exacting medical procedure. In no other act are the patient's life and welfare so immediately and exactly controlled and manipulated. No other diagnoses must be more exact than the minute to minute diagnoses during anesthesia. No other drugs are given to such exact physiologic limits as are anesthetics; no other must be given taken away or antidoted so precisely.

**General Considerations**—Analgesia is the absence of the sensation of pain; anesthesia is the absence of all sensation while general anesthesia is the absence of sensation throughout the entire body accompanied by unconsciousness. These effects are brought about by the action of certain agents on the nervous system. The special characteristics of nerve cells are irritability and conductivity. Conditions such as lack of blood supply or lack of oxygen and agents such as pressure, heat, cold, and anesthetic drugs reduce or abolish irritability and conductivity. Some authorities state that whatever the agent, anesthesia is accomplished (i.e., irritability and conductivity are abolished) by keeping the requisite amount of oxygen out of the nerve cell. The term "anesthesia" does not fully describe the effect produced by anesthetic agents. Not only are sensation and consciousness abolished but frequently the efferent paths also are paralyzed, suspending the function of glands and muscles. Anesthesia then denotes the induced loss of irritability and conductivity with insensibility, inhibition or paralysis in any part of the nervous system, afferent, central or efferent. Tone or tonicity is, according to Stedman, a state of normal elastic tension of the tissues by virtue of which the parts are kept in shape and as it were alert and ready to function in response to a suitable stimulus. Tone is present as long as the efferent nerve path is normal even though unstimulated. Tone is abolished if the efferent nerve path is entirely deprived of its irritability and conduc-

tivity. Surgical anesthesia is loss of sensation with mental and muscular relaxation sufficient to permit operative work.

In general anesthesia the agent or agents are brought into contact with the nervous system through the blood stream. Approaches to the blood stream in the order of their rapidity are as follows: intravenously by inhalation, subcutaneously by colonic absorption and by stomach. Each anesthetic on account of its physical and chemical properties is suitable only for certain avenues of introduction. When distributed by the blood stream the drug is present in all the tissues of the body in approximately the same concentration but is manifested principally in the nervous system. The various parts of the nervous system are not equally affected by the same concentration of an anesthetic. In general those parts which are newer in evolution and less necessary for the maintenance of life are more easily affected by weaker concentration while those parts which are older and more necessary for life require stronger concentrations to affect them. This rule is not at all invariable. Certain anesthetics affect certain nerve elements differently in point of sequence and degree. Nevertheless, the parts of the nervous system succumb to all anesthetics in sufficiently regular sequence so that this sequence may be used as an index of the stages into which anesthesia is divided. Each stage of anesthesia represents diminution of irritability and conductivity, i.e., the inhibition or paralysis of certain parts of the nervous system.

As the concentration of the anesthetic in the blood stream and in the tissues is increased from nothing to the lethal dose the parts of the nervous system are inhibited and paralyzed in approximately the following order:

1. The higher centers. Inhibitions, orientation, emotions, memory, will, sensation, consciousness.
2. The spinal and cranial nerve reflexes.

From the clinical evidence it would seem that these are blocked by anesthetizing one or more neurons on the sensory side of the arc

- a The reflexes from the periphery through the brain stem or spinal cord to the voluntary muscles including the respiratory muscles
  - b The reflexes from the periphery through the spinal cord to the sympathetic (thoracolumbar autonomic) system
- 3 The efferent or motor neurons to most voluntary muscles
- 4 a The parasympathetic (craniosacral autonomic) system
  - b The vasomotor center
  - c The respiratory center

**Stages of Anesthesia**—Anesthesia is described in four stages corresponding to the parts of the nervous system affected

**First Stage Induction Analgesia**—This stage is entered as soon as the administration begins. It is characterized by waning sensation and consciousness. As this stage progresses the inhibitions, orientation, emotions, memory, will, sensation and consciousness wane and disappear in approximately the order named. Sensation may begin to wane from the very first but may not entirely disappear until just before unconsciousness, thus giving a considerable period of analgesia.

**Second Stage Light Anesthesia**—This stage is entered when consciousness has completely gone. It is characterized by unconsciousness with remaining activity of the sympathetic reflexes and the voluntary muscle reflexes, including those of the respiratory muscles. As this stage progresses the sensory or afferent neurons become increasingly anesthetized so that the reflexes diminish. The muscles remain in tone.

**Third Stage Surgical Anesthesia**—This stage is entered when the sympathetic and voluntary muscle reflexes, including the respiratory, have disappeared. It is characterized by unconsciousness and absence of reflexes; that is stimulation may be applied to any field without evoking a sympathetic, muscular or respiratory response. If a motor nerve is directly stimulated, however, the corresponding muscles contract. As this

stage progresses the motor or efferent neurons apparently become progressively anesthetized so that the chest muscles move less and less in respiration until they cease and the tone of the abdominal and skeletal muscles diminishes, relaxation becoming more and more complete.

**Fourth Stage Overdose**—This stage is entered when the parasympathetics and the vasomotor and respiratory centers, especially the last, become paralyzed. It is characterized by unconsciousness, absence of reflexes, great relaxation and failing centers.

**Signs of Anesthesia**—The signs of anesthesia are the physical evidences which denote the activity, inhibition or paralysis of the various parts of the nervous system. For convenience in observation the signs of anesthesia are grouped as follows: (1) sensory signs, (2) motor or muscular signs, (3) respiratory signs, (4) eye signs and (5) circulatory signs.

**Sensory Signs**—Sensation is present in diminishing degree during the first stage only. Conscious discomfort due to the inhalation of the anesthetic is shown by holding the breath, repeated swallowing, clearing the throat, vocally protesting, and moving the head or other parts of the body. Discomfort due to the operative preparation is usually shown by speaking or struggling.

**Motor or Muscular Signs** *First Stage*—During this stage the voluntary muscles are all activated by both the will and the reflex stimulation. As this stage progresses the will becomes anesthetized and the muscles can be voluntarily moved less and less. The voluntary muscle reflex arcs are still active and any muscles may contract in response to sensory stimulation applied to any region of the body.

*Second Stage*—The will has been anesthetized. Voluntary movement has been abolished. The voluntary muscle reflex arcs are still active and any muscles may contract in response to sensory stimulation anywhere in the body. The eyelids resist opening. The eyeballs are widely moving or widely eccentric, especially in response to sensory stimulation and even in a remote area. The jaws resist opening. The arm and leg resist falling if lifted and dropped. The abdominal muscles are rigid. They resist retraction and tend to extrude the viscera.

if the abdomen is open. As this stage progresses the reflex responses become less and less.

### *Third Stage Four Planes A, B, C, and D*

—The afferent side of the voluntary muscle reflex arcs has been anesthetized and the muscles do not respond to sensory stimulation. *Plane A* The eyelids may be opened without resistance. The eyeballs are slightly moving or eccentric. The jaws may be opened without resistance. The mandible may even open and recede spontaneously by its own weight and thus obstruct respiration. The arm and leg fall without resistance if lifted and dropped. The muscles are still in tone and fairly firm especially those of the abdomen, so that with the abdomen open the viscera are somewhat under pressure and tend to escape. The muscles, however, do not contract in response to retraction or other stimulation. *Plane B* The eyeballs are fixed in the center looking straight forward parallel to each other. The muscles are less firm. *Plane C* The motor neurons are apparently becoming anesthetized; the muscle tone is definitely diminishing and the muscles are becoming more and more flaccid allowing free retraction and stretching. *Plane D* The voluntary motor or efferent pathways have become anesthetized, and the muscles are flaccid.

### *Fourth Stage—Flaccidity remains*

**RESPIRATORY SIGNS**—In the administration of an anesthetic all the factors which influence respiration are being constantly manipulated.

Respiration<sup>1</sup> is modified by the will and the reflexes but is carried on by the respiratory center. The latter so regulates respiration as to keep the diffusion pressure of oxygen and the pH of the blood at practically constant levels. A beginning lack of oxygen through its effect upon the carotid body stimulates the center to produce more rapid respiration in an effort to acquire more oxygen. Carbon dioxide produced from the consumed oxygen at a practically constant rate during anesthesia accumulates and lowers the pH to the stimulating point at regular intervals thus initiating succeeding cycles of respiration which in turn reduce the carbon dioxide content of the blood. Increased retention of carbon dioxide stimulates the respiratory center to produce first increased amplitude then also an increased rate of respiration in an effort to excrete the excess carbon dioxide. Increased pressure of gas into the lung causes greater expansion and requires greater stimulation by carbon dioxide and the Hering-Breuer<sup>2</sup> reflex and thus a greater excitement of the respiratory center to accomplish respiration. Obstruc-

tion brings the same result. All these factors stimulate the respiratory center, but if the stimulated effort continues too long and especially if it is unavailing in restoring the oxygen and carbon dioxide to the normal levels the respiratory center becomes fatigued and damaged.

In addition to the constant manipulation of these factors the dose of the anesthetic is being administered and regulated. Primarily the dose of the anesthetic determines the stage of anesthesia and the character of the respiration which indicates the stage and results from it. It must also be constantly remembered that the other factors which fatigue and damage the respiratory apparatus namely continued excess resistance or obstruction to respiration, continued excess carbon dioxide and especially continued and excessive oxygen lack add to and also themselves produce an anesthesia rapidly advancing to death. An uncorrected oxygen lack is especially damaging. If the rapid respiration of early oxygen lack fails to restore the oxygen but succeeds in washing out the carbon dioxide then respiration ceases because it is both paralyzed and unstimulated and anoxemia becomes immediately overwhelming.

**First Stage Induction**—During this stage respiration is carried on by the respiratory center but is modified by the will and the reflexes. As this stage progresses, the will becomes anesthetized and respiration is changed voluntarily less and less. The reflex arcs however, are still active and in response to stimulation applied anywhere in the body, any type of change or irregularity in respiration may take place. Holding the breath and straining on expiration are the two most common responses but any change in rate, rhythm, amplitude or force may occur.

**Second Stage**—When the second stage is entered, the will has been anesthetized. There is no voluntary change in respiration. The reflex arcs are active and may cause any type of change in respiration as just described for the first stage. As this stage progresses the afferent side of the reflex arcs becomes more and more anesthetized and reflex response in respiration becomes less and less.

**Third Stage Four Planes A, B, C, D**—When the third stage is entered, the will is anesthetized. The afferent side of the reflex arcs has become anesthetized, and no reflex irregularity in respiration takes place. The respiratory center and the efferent paths to the respiratory muscles are still active. *Plane A* Third stage breathing, as carried on by the respiratory center mechanism un-

hampered is like the swing of a pendulum—regular rhythmic automatic Inspiration and expiration are equal to each other in time amplitude and force. There is no pause between and each shades into the other. *Plane B* Respiration is the same in character as in plane A but usually a little deeper and more stertorous because there is more general relaxation of the muscles of the throat neck and trunk. *Plane C* As this plane progresses the efferent neurons to the intercostal muscles apparently become more and more anesthetized so that the chest excursion lags more and more behind the diaphragm in point of time and becomes less and less in amplitude. The movement of the diaphragm however being the last defense outpost remains unimpaired. *Plane D* The will the reflexes and the efferent paths to the intercostal muscles have all been anesthetized. The chest does not expand at all with inspiration. In fact when the diaphragm descends the chest because of its complete relaxation may even be sucked inward. As this stage progresses the respiratory center and the efferent paths through the phrenic nerves to the diaphragm become increasingly anesthetized. The diaphragmatic excursion becomes reduced. As the center becomes less sensitive a greater fall in the pH is a greater accumulation of carbon dioxide is required to stimulate it. The interval therefore becomes longer. Inspiration becomes progressively shorter quicker more gasping in type. Expiration becomes progressively longer and less forceful followed by a progressively lengthening pause until respiration ceases. In cyclopropane anesthesia this type of depressed respiration does not occur but respiration remains regular and rhythmic gradually fading in amplitude until it ceases.

*Fourth Stage*—This period follows cessation of respiration while the heart is still beating and life still remains.

The signs consist in the changes in behavior of the eyelids eyeballs pupils and lacrimal glands. The behavior of the lids and globes has already been described under the subject of muscular signs. The iris is composed of radial muscle fibers supplied by the sympathetic and circular fibers which in turn are supplied by the parasympathetic system. In addition to this there are radial

strands of elastic tissue. The lacrimal glands have a double innervation from both the sympathetic and the parasympathetic system. The sympathetic innervation produces tears in response to emotional and remote reflex stimulation while the parasympathetic reflex supplies the normal moisture and probably that excess needed to defend against foreign substances.

*First Stage*—The eyelids and globes move at will and in reflex response. The pupils may dilate and the eyes may be wet in response to fear or other emotion or in response to sensory reflex stimulation. According to Gellhorn<sup>3</sup> Braunstein and Bain Irving and McSwiney<sup>4</sup> dilatation of the pupils in response to pain is produced by inhibition of the parasympathetics rather than by stimulation of the sympathetic.

*Second Stage*—When this stage is entered the will has been anesthetized. The reflexes to the voluntary muscles and the sympathetic reflexes are still active. The lids may be rigid and the globes moving or eccentric. The pupils may be dilated and lacrimation may be excessive. All these signs are due to reflex stimulation and may be absent if there is no stimulation. As this stage progresses these effects become less and less. The light reflex is very active.

*Third Stage Four Planes A B C D*—When this stage is entered there is no voluntary movement. There is almost no reflex response by the globes. The sympathetic system has been anesthetized. The parasympathetic innervation is still in tone. In plane A the lids are relaxed the globes are slightly moving or eccentric and normally moist. The pupils are constricted. The light reflex is therefore not in evidence. As this stage progresses the voluntary muscles become more and more relaxed so that in planes B C and D the eyeballs are fixed in the center looking straight forward parallel to each other. In plane D the parasympathetic innervation becomes more and more anesthetized. The pupils become more and more dilated and the light reflex diminishes at the same rate until with large dilatation the light reflex is entirely abolished. The eyeballs become increasingly dry. With cyclopropane anesthesia the pupils in most cases do not dilate until respiration ceases and oxygen lack comes on.

**CIRCULATORY SIGNS** have a double significance. They help to indicate the stage of anesthesia and also indicate the vital condition, i. e. the ability of the patient to withstand the ordeal of the illness or injury, anesthesia and operation.

**Cyanosis** indicates lack of sufficient oxygen to change all the hemoglobin to oxyhemoglobin. It may be local or general. For instance, with the Trendelenburg position the face may be somewhat dark because of slackened circulation there, although the rest of the blood may be normal. In a person who has ample hemoglobin slight cyanosis is easily seen yet even with the hemoglobin unsaturated the vital centers may still be sufficiently supplied with oxygen. In a person who is anemic or in shock and therefore pale cyanosis is much less noticeable even though the vital centers may be actually suffering from a want of oxygen. With pallor cyanosis appears as a dirty gray and is of grave significance. Cyanosis then is a warning of oxygen lack. It should be heeded and the anesthetist should be still more alert for other circulatory or respiratory signs of oxygen want. Cyanosis is not however a dependable and final criterion. It sometimes may be considered necessary to carry plethoric persons in some degree of cyanosis in order to have them well anesthetized with a gas, the vital centers still showing no impairment but the author believes that no cyanosis should be tolerated.

**Pallor** indicates anemia or shock. If this is due to an illness or injury before operation it presents an added risk and should be met if possible by suitable treatment before the ordeal of anesthesia and operation is added. If pallor is noted during operation, it is due to hemorrhage or shock.

**Pulse**—A slow strong pulse indicates parasympathetic stimulation. A rapid strong pulse indicates sympathetic stimulation which may be caused by hyperthyroidism or by operative stimulation without sufficient anesthesia of the sympathetic nerves. A rapid weak pulse indicates debility, anemia, hemorrhage or shock before operation, hemorrhage or shock during operation or collapse of the vasomotor and cardiac centers due to overstimulation by operative manipulation under insufficient anesthetic or due to too much anesthetic, too little oxygen or a con-

tinued great excess of carbon dioxide. A slow weak or irregular pulse may occur as the terminal stage of the fast weak pulse or may occur primarily following an overdose of chloroform or cyclopropane.

Cyclopropane depresses the pace maker and increases the irritability of the rest of the conduction mechanism. A concentration of cyclopropane to which the individual heart is sensitive therefore causes slowing of the rate with the occurrence of auricular or ventricular extrasystoles which tend to merge into ventricular tachycardia and finally ventricular fibrillation. In the early stages this effect is easily reversible.

**Blood Pressure**—Increased blood pressure indicates sympathetic stimulation. This may be caused by (a) hyperthyroidism (b) operative stimulation without sufficient anesthesia of the sympathetic nerves (c) stimulation of the vasomotor center by moderate oxygen want or (d) stimulation of the vasomotor center by moderate excess of carbon dioxide. Decreased blood pressure may be caused by (a) preoperative debility, anemia, hemorrhage or shock (b) hemorrhage during operation (c) shock due to severe surgical trauma during operation (d) continued surgical manipulation with insufficient anesthesia fatiguing the sympathetic system and (e) collapse of the vasomotor and cardiac centers and perhaps the heart muscle due to too much anesthetic, too little oxygen or a continued great excess of carbon dioxide.

**Preparation for General Anesthesia**—No cathartic should be given but a plain enema the evening before is desirable if possible. Every effort should be made to promote the patient's confidence and to minimize the psychic trauma.

**Preanesthetic Medication**—**ANALGESIC** EFFECTIVE ADULT DOSES. Pentobarbital sodium  $1\frac{1}{2}$  grains one and one half hours before anesthesia. Morphine sulfate  $\frac{1}{2}$  gram plus atropine sulfate  $\frac{1}{4}$  or  $\frac{1}{2}$  grain or scopolamine  $\frac{1}{2}$  or 1 grain three fourths hour before anesthesia. This should be increased for especially large and vigorous adults and decreased for those who are small, frail, weak, debilitated, anemic or aged. For patients over sixty special care must be taken to estimate debility. For all adults the dose is varied according to variations from the



average size nutrition hemoglobin vigor etc

**DOSAGE FOR CHILDREN** The accompanying table is a good guide for children's preparatory medication. Traditionally children do not take morphine well. Practically the writer and many others have found that they take the doses cited very well and it is a great help in safe and smooth anesthetic

atropine, scopolamine or hyoscine, regardless of the time.

**INTRAVENOUS ADMINISTRATION** If sedation proves to be insufficient for satisfactory conduct of local or regional anesthesia or for smooth induction of general anesthesia it may be produced or fortified by morphine sulfate intravenously  $\frac{1}{4}$  grain dissolved in 2 cc of water and injected very slowly until

TABLE 14.—PREANESTHETIC MEDICATION

		DRUGS AND DOSAGE ORDERED		SIMPLIFIED METHOD OF ADMINISTRATION PER HYPODERMIC		
Patient's Age Years	Patient's Weight Pounds	Morphine Sulfate Grains	Hyoscine Hydrobromide Grains	Tablets to Use	Preparation of Solution	Amount of Solution to Use Cc
Under 6 Mo	Under 15	None	$\frac{1}{16}$ o	1 tablet hyoscine hydrobromide gr $\frac{1}{1000}$	Dissolve 1 tablet in 2 cc of sterile distilled water	0.3
6 to 11 Mo	21	None	$\frac{1}{1000}$			0.4
1 and 2	21-30	$\frac{1}{16}$ o	$\frac{1}{1000}$	1 tablet hyoscine hydrobromide gr $\frac{1}{1000}$ plus	Dissolve both of these tablets in 2 cc of sterile distilled water	0.5
3 and 4	31-35	$\frac{1}{32}$ o	$\frac{1}{1000}$			0.7
5 and 6	36-46	$\frac{1}{16}$ o	$\frac{1}{600}$	1 tablet of morphine sulfate gr $\frac{1}{16}$		0.8
7 and 8	47-55	$\frac{1}{16}$ o	$\frac{1}{600}$			1
9 and 10	56-63	$\frac{1}{16}$ o	$\frac{1}{400}$			1.1
11 and 12	64-78	$\frac{1}{16}$ o	$\frac{1}{200}$			1.3
13 and 14	79-100	$\frac{1}{16}$ o	$\frac{1}{200}$			1.3
15 and 16	100-140	$\frac{1}{8}$ o	$\frac{1}{400}$	1 tablet hyoscine hydrobromide gr $\frac{1}{1000}$ plus	Dissolve both of these tablets in 2 cc of sterile distilled water	1.5
17 and 18	140-140	$\frac{1}{8}$ o	$\frac{1}{400}$			2
Over 18	140-160	$\frac{1}{8}$ o	$\frac{1}{400}$	1 tablet of M.S. gr $\frac{1}{10}$		
Especially large and vigorous adults		$\frac{1}{4}$ o	$\frac{1}{16}$ o	11 M.S. gr $\frac{1}{150}$ MS gr $\frac{1}{4}$	2 cc	2

administration. Preparatory barbiturates should not be given with these doses. All preoperative hypodermic medication is to be given exactly forty five minutes before operation. If the child is especially vigorous or overdeveloped the dosage for the next older age group is given. If a child is debilitated, underweight, anemic or suffering from chronic illness the dosage for the next younger age group is given. A child should never be sent to the operating room without

the patient feels any one or more of the following symptoms: general warmth, slight dizziness, weakness or sleepiness or tingling numbness or neuralgic discomfort in any extremity or in the back. Any discomfort will immediately cease. The patient will usually become calm and remain quiet and cooperative. Too rapid injection may cause convulsions. Intravenous morphine sedation is excellent for bronchoscopy.

Care must be taken to remove from the

mouth false teeth chewing gum or any other foreign body before operation. The respiratory and pulse rates and the blood pressure should be recorded on the anesthesia chart before the anesthetic is started and frequently during the administration.

**Anesthetic Agents**—Discussion of the details of technique of the administration of various agents is not included in the scope of this article.

*Ethyl ether* was for over fifty years the most commonly used anesthetic. When not contraindicated it is still very generally used for operations requiring complete relaxation. It is administered by (a) the semi-open mask (b) oral insufflation (c) pharyngeal insufflation (d) intratracheal insufflation (e) vaporization with oxygen or one of the anesthetic gases or (f) colonic injection mixed with equal parts of olive or vegetable oil.

*Divinyl ether* ( $C_4H_8$ ),  $O$  is a highly volatile liquid more potent and more rapid than ethyl ether which can be administered in all the ways suitable for ethyl ether. It is more pleasant for the patient and it is probably being increasingly employed. It is used on a very small and closely fitting mask to prevent excessive loss by vaporization. Its special field is for short procedures or for pleasant quick induction before ether is given especially for children. It produces any degree of anesthesia rapidly. Recovery is swiftly complete so that the patient can very soon go about his usual activity. Practically never is nausea produced. Most investigators have reported no damage to any tissues but some instances of hepatic damage have been noted after repeated or prolonged administration. Except for its inflammability it has taken away all need for using chloroform.

*Chloroform* is administered on the open mask. Because of its many good qualities it was once used very generally but because of the added immediate cardiac risk and danger of hepatic damage it is now little used except for certain cases in which a powerful and non inflammable agent is required as in malignant tumors of the head. Some surgeons insist on using it for convenience in obstetrical cases but this is a very questionable procedure.

*Ethyl chloride* on the open mask is very

pleasant and serviceable for short operations but it must be used with skill and caution and only by those who have had sufficient training. It tends to produce fatal spasticity of the respiratory muscles.

*Nitrous oxide* the first and weakest gas anesthetic is administered with just enough oxygen to supply the metabolic need and does not produce good surgical anesthesia unless the oxygen is reduced to or below the very margin of oxygen want. A little carbon dioxide may possibly be allowed to accumulate for respiratory stimulation and to combat the tendency to oxygen want.

*Ethylene* is a more powerful gas anesthetic and is given by the same technique. It produces somewhat more complete anesthesia with less limitation of oxygen.

*Cyclopropane*<sup>5-7</sup> is a powerful gas which produces almost complete relaxation and is administered by mixing a small quantity from 5 to about 35 per cent of cyclopropane with 65 to 95 per cent of oxygen.

All gas anesthetics are best given by the completely closed method allowing as little escape of gas as is possible and absorbing with soda lime as much of the accumulating carbon dioxide as may be eliminated. Ether vapor may be added if sufficient relaxation is not otherwise obtainable. The administration of inhalation anesthetics through an intratracheal tube<sup>1</sup> provides entirely unobstructed respiration controlled ventilation improved relaxation and easy removal of bronchial secretion and is indispensable in certain operations on the chest neck and head. At the conclusion of inhalation anesthesia recovery is facilitated and nausea largely obviated by hyperventilation with oxygen. After this expansion of the lungs with air by means of moderate bag pressure helps to prevent atelectasis because nitrogen is much less quickly absorbed from the lungs than is oxygen. Instead of air helium with oxygen may be used with as good or better effect.

*Avertin*<sup>8</sup> (tribromethanol) is given by colonic injection for basal anesthesia in a dose generally not to exceed 70 to 80 mg per kilogram of body weight and is then supplemented if necessary by nitrous oxide or chloroform by inhalation or by pentothal sodium intravenously for cautery operations. Avertin is very useful for thyroidectomies.

and for induction of anesthesia in apprehensive children. Many anesthetists are again using avertin for more complete anesthesia judging the dose by the type of patient. The basal caloric requirement seems to be the best index of the required dose.

*Sodium amytal*<sup>10 11</sup> by intravenous injection has been used for general anesthesia in a dose of from 13 to 16 Gm in 20 cc of distilled water. The production of surgical anesthesia in this way has lost greatly in popularity largely because of the long time required for recovery and the untoward mental and nervous symptoms which too frequently follow so large a dose.

*Pentobarbital sodium*<sup>10 11</sup> (nembutal) in half the above dose produces equal anesthesia and less untoward after effects but has gained little popularity.

The two barbiturates just mentioned now find their most suitable intravenous use in prolonged or sustained control of severe convulsive states or intermittent control of intractable pain.

*Sodium euphan*<sup>9</sup> or *euphal soluble* and *pentothal* (thiopentobarbital) *sodium*<sup>10 11</sup> are the latest barbiturate anesthetics and have become well established. They are given intravenously in 5 per cent or preferably 2.5 per cent solution slowly about 1 cc each five seconds until the patient is unconscious and then 0.5 or 1 cc is added as needed to maintain anesthesia. Complete relaxation should not be sought as the respiratory center is thus endangered.

Pentothal sodium has proved to be so useful for such a wide variety of procedures that in some large hospitals it is used either alone or in combination with other anesthetics and methods in from 80 to 95 per cent of all cases. It is by far the most pleasant anesthetic available. The accepted duration of administration has gradually been increased up to two or three hours and it has been administered without detriment for as long as eight or nine hours. After a short period of anesthesia recovery takes place in fifteen or twenty minutes. After a long period recovery may require many hours with depression lasting long enough to increase the hazard of atelectasis. This is a serious disadvantage in pentothal sodium a disadvantage which has prevented the use of intravenous anesthesia for major

surgical procedures in most hospitals. One of the best uses for intravenous anesthesia is to produce unconsciousness to supplement spinal anesthesia or nerve block.

*Curare*—The most spectacular advance in anesthesia in the last few years has been the use of curare to produce relaxation. A preparation of this drug is now available in sufficiently purified form to produce well controlled effects with apparently no harmful side effects. Patients may be carried under very light general anesthesia no deeper than plane 1 of the third stage and relaxation of any desired degree may be produced by the intravenous injection of 10 to 120 units of curare. The effect comes on in approximately one minute. A conservative dose should at first be injected and additional doses of 20 units should be injected at one minute intervals until the desired relaxation is produced. Various muscle groups are relaxed in the order of their susceptibility the diaphragm being the last affected and the intercostals and abdominal muscles just before the diaphragm. If the diaphragm should be paralyzed artificial respiration by intermittent pressure upon the breathing bag is the only antidote necessary. Curare should never be given unless the anesthetist is certain that his mask fits properly the patient's airway can be maintained and he can inflate the lungs by bag pressure. Prostigmine is the drug antidote but its use has never been found necessary by the writer. Cyclopropane is the best suited general anesthetic for combined use with curare but it may be used with others if the anesthetist is especially careful about the dose. Duration of curare effect varies from thirty to ninety minutes. It may then be repeated. One half to two thirds of the first dose is usually sufficient for the second dose.

*Combined Anesthesia*—The greatest characteristic of successful modern anesthesia is the combined use of different perhaps several anesthetics and methods. Examples of this are the combined use of spinal and intravenous anesthesia, nerve block and intravenous anesthesia, intravenous induction followed by inhalation maintenance of anesthesia, intravenous induction of unconsciousness before the procedure of nerve block or spinal anesthesia and the combina-

tion of inhalation anesthesia of any type with the concurrent use of intravenous anesthesia. The use of combinations makes it possible to use a minimum of each drug with consequent rapid recovery. It is possible in this way to use each drug or method for its greatest advantage and not to call upon any of them for effects which can be produced only by a large dose.

**Explosion Hazards**—Explosion may occur when a mixture of ether, ethylene or cyclopropane with nitrous oxide or oxygen is exposed to a flame or spark within the respiratory tract, breathing tubes or bag or tanks or within about 2 feet of any point of escape therefrom. Under certain special conditions the distance may be greater according to some authorities. The writer has never been able to collect an explosive sample of gas as far as 3 inches from the open end of the respiratory tubing with three times the customary amount of an explosive anesthetic mixture flowing from the machine.

The most effective prevention is (1) avoidance of static spark by having a relative humidity above 55 per cent, which continuously and equally grounds all persons and objects in the room and (2) keeping electric and hot instruments out of the chest and farther than 2 feet from the mask and apparatus. Anesthesia with CO absorption and a completely closed respiratory circuit greatly reduces the hazard by providing adequate inside humidity and by minimizing the gas escape. Gas must be prevented from entering a tank containing another gas.

Metal or metal and water grounding of all objects in the room is effective against static but is practically impossible. Metal grounding of the machine alone is unwise in that it invites other objects and persons charged with static to spark against the patient, anesthetist and machine. Electrical instruments must not be used in the presence of metal grounding because of the danger of short circuits.

An intercoupler which equalizes the potentials of the patient, anesthetist, anesthesia machine and operating table is a wise provision.

Certain proportional mixtures of ethylene, cyclopropane and oxygen are non-inflammable and if accurately controlled mixtures of these three may be kept non-explosive and still may produce any plane of anesthesia. Dilution of cyclopropane-oxygen mixtures with helium or nitrogen in proper proportions also makes them non-explosive.

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#### REGIONAL ANESTHESIA AND NERVE BLOCK

Never in history have so many surgical operations been performed under local, regional and spinal anesthesia as during these current days of World War II. The exigencies of battle, ashore and afloat, and conditions of personnel and supply at base establishments have combined to favor widespread use of injection techniques. Former stages of experimentation, controversy and uncertainty prevalent until recent years have abruptly been set aside, leaving nerve blocking methods the procedure of clearcut choice for most military and a considerable proportion of civilian operations. Today operations by the hundred of thousands are routinely performed without resort to inhalation narcosis.

**Advantages of Nerve Block**—Reasons for this preference for nerve block are numerous, only a few illustrations needing to be cited. 1 The conscious cooperation of the patient is retained, alertness being but slightly dulled through judicious use of premedication given to allay apprehension. It is highly advantageous that the patient be able to move a limb to breathe deeply or to cough at the direction of the surgeon. 2 The surgeon, if he so desires, can work without the aid of a special anesthetist, a consideration of moment in certain emergencies, either military or civil. 3 The airways remain patent and sensitive respiratory mucous membranes sustain no pathologic injury. 4 Medullary centers are protected. 5 Damage to liver, kidney and other vital organs is minimal. 6 The injurious inflow of noxious sensory stimuli from the periphery or operative site is cut off. This is not the case under inhalation or intravenous anesthesia, where the patient is rendered incapable of response while such a bombardment continues. 7 The patient often is able to walk from the surgical amphitheater and to help himself to take nourishment promptly to cooperate in the frequent postural changes important in the prevention of thrombosis and embolism. All in all, operations are shorn of much of the character of dreaded ordeals.

**Historical.**—The ability to blockade sensory stimuli at their seat of origin at the periphery began with the discovery by Carl Koller, a student of ophthalmology in Vienna on Sept 15 1884 that operations on the eye could be painlessly performed after topical applications of cocaine. The significance of this discovery was immediately recognized throughout the surgical world and rapid advances followed. American surgeons (Halsted Cushing Crile Matas) played an important role in bringing the advantages of the method to all departments of surgical work. The toxicity of cocaine however and its habit forming properties proved almost insurmountable difficulties in attempts to standardize this form of pain control. Only when Einhorn more than twenty years thereafter (1905) introduced *novocain* an anesthetic agent but one-seventh as toxic as cocaine was sound and permanent progress in this field made possible which led to the development of the more elaborate technical methods now in use. Simultaneous blockade of many large nerve trunks (paravertebral block) or of complete plexuses (brachial block cervical plexus block) and of entire regions of the body now had their advent.

In 1927 alcohol nerve block was introduced rendering pain-control permanent or semi permanent when so desired depending on the strength of the solution employed. Therapeutic nerve block for intractable pain as in carcinoma and a wide variety of injection techniques for treatment followed and during this period rapid development of diagnostic nerve block and prognostic block was observed.

**Stages of Development of Regional Anesthesia.**—Seven distinct stages have marked the three-score years of development of regional anesthesia namely, the four just cited and three of more recent origin.

- 1 Discovery of the clinical use of cocaine (1881)
- 2 Introduction of *novocain* (1905), followed by that of other less toxic anesthetic agents
- 3 A phase of rapid extension of diagnostic therapeutic and prognostic nerve block (1910-1930)
- 4 Advent of alcohol nerve block (1927) for permanent or semi permanent destruction of sensory fibers
- 5 Continuous nerve block wherein a weak solution of an anesthetic agent is applied for many hours even days while the injection needle catheter or cannula remains in situ. Thus child birth and operations of unusual length have been brought within the domain of regional nerve blocking techniques

6 The sixth stage is the current one of universal military acceptance and routine application.

7 There remains the seventh and final stage that of chemiophysiological isolation of individual nerve fibers and fibrils. It is seen that most of the peaks in progress coincided with the introduction of new drugs demonstrating the association and interdependence of surgical and of chemical and biochemical progress. New drugs are now appearing with selective affinities for exclusive or dominant action on individual components of the nerve bundles. Thus for example vasoconstrictive fibers and other autonomic and visceral motor fibers are beginning to be controlled by nerve block methods just as reliably as have purely sensory components hitherto. All parts and regions of the body are now within the domain of the injection methods under discussion.

## SCOPE OF NERVE BLOCKING METHODS

It is readily apparent that regional anesthesia has long since outlived its original name. The terms anesthesia and analgesia no longer prove adequate to indicate the full scope of nerve blocking procedures. Regional anesthesia, within a short span of years has reached a point from which it sends ramifications into every branch of medicine and to each of the medical specialties and the role it plays in these several domains is not minor but one of ever increasing importance.

**Diagnostic Nerve Block.**—Diagnostic nerve block may be defined as nerve blockade for the purpose of differentiating one condition from another.

The impulses for pain in biliary colic for example are carried over the ninth intercostal nerves and their associated white ram communicantes while those of renal colic traverse the first lumbar nerves and those of angina pectoris travel over pathways between the second and sixth thoracic trunks thus by appropriate injections to block these impulses such as mild disease entities and syndromes may be tentatively diagnosed facilitated. Another example of diagnostic block is to be found in the field of peripheral vascular disease. It was early noted that an area which had been rendered anesthetic through nerve block injections shows an increase in the skin temperature distal to the site of injection and as the study of vascular disease advanced it was proved that nerve block released the area concerned from vasoconstrictor control i.e. the sympathetic vasoconstrictor fibers were affected as well as the sensory nerve. It is now possible to differentiate vascular diseases which are primarily vasospastic such as Raynaud's disease from those which are primarily obliterative such as arteriosclerosis. In the entities of the former category release of vasoconstrictor action leads to marked elevation of the surface temperature within the affected part but in the presence of any organic narrowing of the vessel lumen the release of vasoconstriction is insufficient to restore circulatory efficiency to the normal range.

**Prognostic Nerve Block.**—Prognostic nerve block makes it possible to foretell the probable course of a disease and to forecast the results that will follow surgical treatment. The foregoing statements relative to peripheral vascular disease illustrate the possibilities of prognostic nerve block. It has been demonstrated that the alterations in circulatory efficiency that follow blockade of vasomotor pathways with local anesthetic solutions approximately parallel those to be expected from surgical destruction of the same pathways (sympathetic ganglionectomy or ramisection). The patient may

then be given an actual preoperative sample of the state that will be surgically produced.

**Therapeutic Nerve Block**—Therapeutic nerve block signifies temporary or permanent control of nerve impulses for purposes of treatment. Injections of sensory paths and nerve trunks may be made in the treatment of sciatica, tic douloureux, angina pectoris, incurable carcinoma and other painful states. Therapeutic nerve block for thrombophlebitis has also gained popularity. In fact many of the techniques originated to provide temporary insensitivity for the purpose of aiding surgical intervention have now come to be used for permanent insensitivity and to make surgical intervention needless.

The question has well been asked: Who would dare predict the end results in the alleviation of human ills that will ultimately result from the deliberate control and conditioning of the multitudinous physiologic activities directly under the dominion of the numerous individual components of peripheral nerve bundles as new injectable agents of high selectivity continue to be advanced?

### TECHNICAL APPLICATIONS

**Needles, Syringes, Solutions**—It is preferable to have needles of fine gauge and where necessary long enough so that the operator can feel the various layers and fascia traversed by the needle point. Some operators prefer to make the intradermal wheel with a sharp needle and use a rather blunt needle for deeper injection, feeling that there will be more resistance from the heavier tissues and that there will be less chance of entering a vessel. Any good syringe that is mechanical in proportion to the gauge of the needle can be used, whether it has an automatic refill or must be detached from the needle to be refilled. Syringes care must be employed so that the correct solution is used for the purpose; accident, high concentrations of stock solutions, alcohol, boracic acid and other fluids have been injected at times with fatal results. In making an injection into the deeper tissues the needle should always be passed through an intradermal wheel. From five to ten minutes must be allowed between the time of injection and that for beginning the operation.

**A. Topical Anesthesia**—*Definition*—Insensitivity produced by direct application of an anesthetic solution (1) to mucous membranes, (2) to serous surfaces or (3) into open wounds.

**1. Mucous Membranes**—Topical anesthesia is extensively used in the work of the

ophthalmologist, rhinolaryngologist, urologist and proctologist. The anesthetic agent is applied in the form of drops or sprays or by means of applicators or pledgets soaked in the solution, occasionally full strength crystals being used. Most operators use solutions such as pontocaine, butyn and nupercaine.

**EYE**—It has been found that 2 per cent solution of pontocaine or butyn gives sufficient insensitivity for the removal of a foreign body from the cornea, however other anesthetics in liquid or ointment form often produce sufficient anesthesia to allow surface operations. For the removal of a cataract or iridectomy, each operator uses the anesthetic he has found most successful.

**NOSE**—Adequate anesthesia of the nasal mucosa is obtained by spraying or directly applying pontocaine or butyn solutions. Quite extensive procedures can be carried out by using this technique—turbineotomy, septum resections, etc.

**PHARYNX AND LARYNX**—The use of anesthesia here is to control local sensation and reflexes and is best done by either spraying the anesthetic directly onto the mucous membranes or by the use of anesthetic lozenges (numerous products are on the market which are manufactured by reputable firms). Lozenges used preceding gas-troscopy are of value.

**URETHRA**—Only the less toxic anesthetic agents should be used in the urethra and bladder because of rapidity of absorption from these surfaces, causing toxic or allergic manifestations. Diothaine (5 per cent) or solutions of pontocaine or metycaine are suitable agents.

**2. Serous Surfaces**—Weak solutions of the less toxic anesthetic agents often produce insensitivity to the surfaces of joint and peritoneal and pleural cavities.

**JOINTS**—Orthopedic procedures such as arthrotomy, removal of loose cartilage, reduction of dislocations and brisement may be carried out with the aid of synovial distention with a weak anesthetic solution. When the joint is to be opened this anesthesia must of course be supplemented by infiltration of the overlying tissues.

**3. Open Wounds**—It is often possible to obtain satisfactory anesthesia within and immediately around an open wound by packing the wound loosely with gauze or cotton

moistened with a dilute solution of one of the effective topical anesthetics. There is danger in the abuse of this method since open vascular channels in the wound may allow rapid absorption of the drug with systemic toxic reactions. However pain and sensitiveness can be so easily reduced in this manner that it is a highly useful procedure in treating comparatively small accidental wounds.

**B Local Anesthesia—Definition—**Local anesthesia is localized insensitivity of the skin or mucous membrane produced by subsurface injection of an anesthetic solution. This is induced either for the removal of purely intracutaneous lesions such as nevi, papillomas and warts or to allow the making of an incision through the surface to give access to the deeper tissues. Local anesthesia is extensively used by the general practitioner, general surgeon and dermatologist who are enabled by this method to perform almost any operation either by nerve block or by infiltration.

*The intradermal wheal* is the basis of all local anesthetic injections. The finest intradermal needle (27 gauge) is attached to a syringe filled with 1 or 2 per cent solution of procaine and passed into the skin. A small wheal is raised. A proper wheal produces a "peau d'orange" or "pig skin" appearance. The anesthesia is instantaneous.

*Removing a Benign Cutaneous Lesion—*The base of the lesion is encircled by wheals which must include sufficient area to allow for wide excision and subsequent suturing of the skin margins.

**C Field Block Anesthesia—Definition—**Field block anesthesia is insensitivity produced by infiltration of the tissues adjacent to the proposed operative field through which pass the sensory nerves of the operative site en route to the spinal cord. This procedure resembles local infiltration in the manner in which it is performed but resembles nerve block in that it effects interruption of the sensory pathways central to rather than within the field of operation. Its advantages over local anesthesia are the lack of distortion of the tissues in the field of operation, the prolonged anesthesia (since none of the fluid escapes through the incision) and the requirement of far less anatomical knowledge than for nerve block. The technical difficulties in creating a diffuse

wall of anesthesia are by no means as great as when the exact seat of an important nerve trunk must be located.

The method is used in the removal of sebaceous cysts, lipomas and other tumors and for surgical exposures in all parts of the body.

*Scalp—*All the sensory nerves supplying the scalp are situated within the subcutaneous tissues. Therefore the entire cranium and scalp can be anesthetized by a zone of infiltration encircling the head.

*Finger—*An encircling zone of field block anesthesia at the base of the finger allows the removal of a foreign body, an incision for drainage, amputation or any operation on the digit. Caution must be taken so as not to use too much solution and overdilate the tissues, especially if the solution contains adrenalin because of the danger of causing necrosis. Infiltration is best made in the web space. The use of adrenalin is not advised.

*Thoracic Wall—*In the removal of ribs for empyema or in performing other operations on the thoracic wall the desired area is widely blocked by infiltrating all the layers. Subcutaneous block in the lateral aspect of the chest wall does not always provide satisfactory anesthesia. This is because the lateral cutaneous branch of the thoracic nerve which accompanies each rib emerges from its deep situation at the side of the chest and becomes subcutaneous there. Therefore even though its point of emergence may be entirely encircled by a zone of infiltration the area within that zone may still be unanesthetized. Paravertebral nerve block may be necessary to provide anesthesia in this particular region.

*Abdominal Wall—*Field block of an entire half of the anterior abdominal wall may be obtained by infiltrating all the layers along the costal margin and thence downward to the crest of the ilium, thus blocking the seventh to eleventh intercostal and iliohypogastric and ilioinguinal nerves. Often partial blocking of either side of the abdominal wall depending upon where the incision is to be made is a valuable adjunct to gas anesthesia producing proper relaxation. This form of technique is routinely used by many surgeons.

*Fractures—*From 10 to 20 cc of a 1 or

and injection of 10 cc This may be given every hour for twelve to fourteen hours if needed

Midcaudal block is used for analgesia of the lower abdomen as in gynecologic surgery cesarean section and hernioplasty Here again an initial dose of 10 cc is given and after five minutes the sacral area is tested The patient is turned in the position required by the surgeon A second injection of 30 cc is made and the table is tilted with the head down 5 degrees This is also suitable for operations upon the lower extremities except that the head of the table is raised 5 degrees

High caudal anesthesia is produced by giving an additional 30 cc above that used in midcaudal block the anesthesia will reach as far as the clavicles or nipples

*Supplementary Injections*—To use continuous caudal anesthesia supplementary injections are needed every thirty or forty minutes when epinephrine is not used or every sixty to ninety minutes with epinephrine depending upon the necessity for the continuation of the analgesia

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CONSTANTINE ODEN

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### SPINAL ANESTHESIA

Spinal anesthesia has been a most valuable contribution to the practice of surgery but it is well to keep in mind that there are dangers attendant on its use just as there

are on the use of any anesthetic Failure to observe certain principles governing its employment will result disastrously The majority of deaths that have occurred have resulted through failure to observe certain fixed rules The student should study one method and master it just as with any other surgical procedure While several methods are now enjoying success the technique of volume control is safe and reliable if accurately followed

When novocain is introduced into the subdural space it bathes the intradural tissues and is quickly absorbed by the nerve roots thus blocking the passage of sensory and motor nerve stimuli The spinal nerve that supply motor stimulation to the sympathetic nerves by way of the white rami communicantes are paralyzed by its upward diffusion a fall in blood pressure occurs as a result of the vasodilation and is probably directly proportional to the extent of sympathetic paralysis which may be gauged by the height of the anesthesia The sensory fibers are more susceptible to the influence of novocain than are the motor fibers To combat the fall in blood pressure Labat Babcock and Vehr advocate the Trendelenburg position which causes the blood to gravitate to the brain and prevents cerebral anemia This position tends to defer cardiac and respiratory failure, despite relaxation of the entire vascular system A fall in blood pressure may be prevented also by the administration of ephedrine prior to the spinal anesthesia Ephedrine is a peripheral acting vascular stimulant and properly administered maintains normal vascular tone despite the paralyzing effect of novocain on the vasomotor fibers in the anterior roots of the cord

It has been found possible to produce spinal anesthesia which can be fairly accurately controlled as to the height of the anesthesia The use of any foreign substance other than novocain in the spinal canal is not required The upward extension of anesthesia is directly proportional to the rapidity of diffusion of the novocain injected the volume of fluid injected and the specific gravity of the solution of novocain it is inversely proportional to the rate of fixation of novocain by nerve tissue It may be influenced by the position of the patient's



body when there exists a difference in specific gravity between the solution injected and the spinal fluid. When the specific gravity of the injected solution is heavier than that of the spinal fluid the Trendelenburg position assumed during or immediately after injection of novocain will accelerate the rate of upward diffusion while Fowler's position will retard it. The dosage of ephedrine is varied in direct proportion to the degree of vasodilatation expected. To be readily absorbed ephedrine should be injected into the interspinous muscles and it should be given five minutes preceding the introduction of novocain.

**Technic**—Important factors in the technique of volume control (Stout) are aspiration of accurately measured volumes of spinal fluid used as a solvent for graded doses of novocain and the re-injection of the solution of spinal fluid and novocain without loss at a constant measured rate. A 22 gauge non breakable spinal puncture needle is used. Multiple punctures and trauma of the cord should be avoided. Graphic records should be kept of the patient's general condition, the height and duration of anesthesia, the blood pressure, pulse rate, drug administration and so forth.

Preoperative preparation depends on the condition of the patient, the nature of the disease and the type and extent of the operation. Time permitting the patient receives in addition to the usual preoperative measures the following:  $1\frac{1}{2}$  grains of nembutal by mouth one-half hour preoperatively, pantopon  $\frac{1}{2}$  grain and scopolamine  $\frac{1}{150}$  grain for the patient under fifty years of age and  $\frac{1}{200}$  grain for the patient over fifty by hypodermic one hour before operation. The scopolamine may be omitted if the patient is calm and the operation not prolonged. These dosages of course are only the average. The importance of individualization of preoperative medication cannot be overstressed.

The blood pressure is recorded and the surgical field prepared and covered with a sterile towel. With the operating table level the patient is placed on his right side, back bowed out, knees up and neck flexed. His position should not be cramped but must be maintained by an assistant. The back is surgically prepared. Ephedrine is then ad-

ministered. The dosage of ephedrine depends on the amount of novocain to be used; it is recommended that 15 mg. be given for each 50 mg. of novocain but this may be altered to satisfy complicating conditions. Thus one hesitates to give ephedrine to a patient with hypertension or advanced arteriosclerosis.

A drop of 1 per cent solution of novocain injected intradermally over the second or third lumbar interspace will minimize the pain of spinal puncture and provide better cooperation. In this area the 22 gauge needle is inserted and carried through the interspinous ligament into the dural sac. This is recognized by a temporary snap and the subsequent lack of resistance.

With the needle in the subdural space the stylet is withdrawn and spinal fluid should flow. It may be necessary to readjust either the direction or the depth of the needle. The syringe is attached and the desired amount of spinal fluid aspirated. One cubic centimeter of spinal fluid for each 100 mg. of novocain used insures a 10 per cent solution; the concentration usually employed in the technique of volume control. (Some workers prefer a 5 to 7 per cent concentration.) The syringe is detached and the stylet replaced. A larger mixing needle is then attached to the syringe and its contents transferred to the ampule of novocain crystals (Metycaine, spinocaine, pontocaine and nupercaine have their advocates.) The dosage of novocain should not commonly exceed 200 mg. although 200 to 300 mg. is used routinely in some clinics for operations on the gallbladder and stomach. The crystals are dissolved by agitating the solution and at the expiration of five minutes from the time of the injection of ephedrine the stylet is removed and the novocain solution injected at the rate of 1 cc. in five seconds. The needle is then withdrawn, the site of puncture covered with sterile gauze and the patient quickly turned on his back.

The level of anesthesia is then carefully observed as it climbs upward. If it does not progress with sufficient rapidity the head of the table may be slightly lowered. As soon as the correct level of anesthesia is reached the table is leveled for ten minutes to assure fixation. While the patient is being draped the anesthetist should record the

blood pressure. The patient first experiences a sensation of warmth and tingling in the feet followed by numbness and inability to move the legs. Occasionally there is nausea due to the falling blood pressure. Adrenalin will often check this fall and then additional ephedrine may be used. Carbon dioxide usually controls the nausea. When the height of anesthesia is fixed the Trendelenburg position may be safely assumed and this likewise counteracts the tendency to nausea by preventing cerebral anemia.

The patient should at all times be under the care of a competent anesthetist who should be ready to administer carbon dioxide and oxygen at the patient's first sign of discomfort. Ampules of adrenalin, ephedrine and pantopon should be available for immediate use. Frequent blood pressure readings should be made. Several sterile sets for spinal anesthesia should always be available. The ampules of novocain crystals, ephedrine and adrenalin may be kept in covered cups containing 70 per cent alcohol.

In recent years in an effort to find a longer acting drug a number of substitutes for novocain have been perfected for use in spinal anesthesia. Pontocaine and nupercaine are the two best known of these preparations. The length of analgesia with pontocaine is about two hours and with nupercaine about three to four hours.

The stock 1 per cent solution of pontocaine has a specific gravity greater than that of spinal fluid therefore a technique similar to that used for novocain can be followed in its use as a spinal anesthetic. Two cubic centimeters of a 1 per cent solution is the maximum dose this being mixed with an equal amount of spinal fluid and injected at the rate of 1 cc. per twenty five seconds. Smaller amounts of ephedrine can be used as the fall in blood pressure is much less than with novocain. Pontocaine is fixed more slowly than novocain however and the patient should not be placed in the Trendelenburg position until at least twenty minutes has elapsed. Pontocaine is also put up in crystalloid form in 10 and 20 mg. ampules. The same technique is used the crystals being dissolved in 2 or 4 cc. of spinal fluid respectively.

Nupercaine solution 1:1500 has been used for spinal anesthesia when an even longer

duration of anesthesia was desired. Since this solution is lighter than spinal fluid an entirely different technique is used and to avoid confusion it will not be discussed here. Hand and Sise have published an excellent article on nupercaine anesthesia in which the technique is carefully discussed.

It must be emphasized that both pontocaine and nupercaine are more toxic than novocain and should be used only by an experienced anesthetist and then only after a careful study of a technique applicable to their use has been made.

A recent development in spinal anesthesia namely the use of continuous or fractional spinal anesthesia eliminates to a large extent the need for the use of the more toxic longer acting anesthetic agents. In this technique a specially designed slotted mattress 5 inches thick and a very flexible special alloy lumbar puncture needle permit the returning of the needle in place in the subarachnoid space throughout the entire operation. The needle is connected to a syringe by means of a 30 inch piece of rubber tubing. Proaine previously mixed with spinal fluid to a 2 per cent strength that is 50 mg. of the drug per 1 cc. of spinal fluid is then injected in fractional doses as needed during the operation. By this method anesthesia can be continued indefinitely while under control at all times. Usually 300 to 500 mg. of novocain dissolved in from 6 to 10 cc. of spinal fluid is sufficient for most operations but as high as 2000 mg. has been used without untoward results.

**Indications and Contraindications for Spinal Anesthesia.**—Spinal anesthesia is especially indicated in all cases in which complete relaxation of the abdomen is desired it should be used in preference to inhalation anesthesia in the presence of an infection of the upper respiratory tract unless specifically contraindicated and it may be used in most cases of major operations below the diaphragm in which it is safe to use inhalation anesthesia.

It was formerly believed that hypotension was a contraindication to the use of spinal anesthesia but careful building up of the blood pressure with ephedrine eliminates this factor. Neither is hypertension a contraindication *per se*. Spinal anesthesia should not be used in patients with severe myo-

cardial damage or advanced arteriosclerosis it is contraindicated in the presence of any disease of the central nervous system.

**Complications.**—The literature contains reports of various complications that have followed the use of spinal anesthesia but only 2 possible fatalities occurred in a series of over 4000 cases at the Jackson Clinic. One of the first patients had convulsions on the operating table and could have been saved with the present day knowledge of the proper technique. Headaches formerly a fairly frequent complication of spinal anesthesia were due to the large caliber of the needle used, traumatization of the cord and loss of fluid. Flexing the foot of the bed to prevent headaches is not required with the proper technique. However the patient should be required to lie flat in bed for twenty-four hours. The writer has observed no paresthesias of more than a transitory status. Meningitis due to a contamination of the solutions, syringes or needles has been reported. The preoperative use of nebulal should obviate the possibility of convulsions resulting from the injection of novocain into the venous plexus around the cord. This danger can be further minimized by carefully observing the rule never to inject when a bloody tap is obtained, as this is always an indication for making a fresh spinal puncture.

**Advantages and Disadvantages.**—The advantages of spinal anesthesia may be judged from the standpoint of the patient, surgeon, nursing staff and relatives. Many patients dread the thought of being put to sleep more than they fear the operation. Pain is usually eliminated as soon as the spinal anesthetic is administered, yet the patient retains full consciousness. Postoperative nausea and vomiting are largely eliminated and distention is decreased. There is no damage to a normal cardiorespiratory vascular system. There is little or no disturbance of the nervous system and the psychic factor of an operation is minimized for the average patient. The patient returns to the room cheerful and smiling and able to converse with relatives. Fluids may be taken before, during and after operation. There is no struggling on awakening, no retching or straining of the wound and consequent pain. There is no mucus to be aspirated. The pa-

tient can cooperate in preventing postoperative atelectasis by deep breathing and assisting in moving.

The advantages of spinal anesthesia to the surgeon may be summarized as follows. Relaxation of the abdominal wall largely eliminates the need of retraction and of wiling off the intestines and permits better exposure of the operative field. The intestines remain in a contracted quiescent state enabling the source of trouble to be more quickly located and alleviated. The time element is further reduced by the ease of closure due to the relaxation of the abdominal wall. The patient can cooperate with the surgeon, a condition which cannot be obtained under a general anesthesia. The surgeon may converse with the patient if necessary.

The advantages to the nursing staff are innumerable. The use of emesis basins and the constant care of the patient after he is returned to his room after a general anesthetic are largely eliminated. The patient is able to cooperate with the nursing staff. The moaning and groaning that disturbs the morale of every one in the hospital is avoided.

The disadvantages of spinal anesthesia are that (1) the operating time is limited unless supplementary inhalation anesthesia or the continuous spinal method is employed; (2) it requires the services of one thoroughly conversant with the technique of its administration and the physiology of its effect on the central nervous system; and (3) it is not a satisfactory anesthesia for little children because of the difficulty of securing a child's cooperation during the administration of the anesthetic.

Caudal anesthesia should be mentioned as a type of spinal anesthesia. It consists in passing a needle through the sacral hiatus and depositing an anesthetic fluid within the sacral canal. The solution is distributed outside the dura mater and the process is thus differentiated from ordinary spinal anesthesia in which the anesthetic agent is introduced into the subarachnoid space. It may be used in a single injection technique or in the continuous manner as popularized lately for use in obstetrics.

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## XLI. PREOPERATIVE AND POSTOPERATIVE CARE

### GENERAL PRINCIPLES OF PRE OPERATIVE TREATMENT

In discussing briefly the preoperative preparation of the patient it is possible to deal only in rather wide generalizations. It is obvious that conditions may radically alter or modify subtract from or add to any course of procedure that might be propounded as a routine method. One need only pause to think of the multitude of factors which may have to be met to realize the complexity of the undertaking. Is the patient young or old thin or fat male or female nervous or phlegmatic sane or insane? Is there a complicating lesion—cardiac pulmonary vascular renal hepatic pancreatic? Does the contemplated surgical operation carry with it the necessity for any special preparations such as is frequently the case with operations on the thyroid thoracic cavity stomach or bowel? Does the anesthetic agent chosen demand preparatory measures? This list scarcely scratches the surface of the multitudinous questions which present themselves to the conscientious surgeon in the preparation of any patient for the ordeal of any operation how ever simple. Certain risks and responsibilities must be shouldered by him owing to the nature of his calling but he is not playing fair with the patient or with himself if he does not make every possible effort to reduce these hazards to the absolute minimum *before the operation*. This then is the goal of all preparatory procedures.

It is most essential that the surgeon should have the complete confidence of the patient in order to obtain absolute cooperation. It is a most difficult if not impossible task to cure a patient *in spite of himself*. To that end it is important to take enough time to talk things over with the patient and the family beforehand—the reasons for the operation its gravity and expected outcome even any unusual or salient points in the preparation for or care after the operation. In this way a mutual understanding is es-

tablished which later may be of invaluable assistance to the surgeon. Not infrequently certain individual characteristics of that particular patient may be discovered which will be of vital assistance or importance in the later handling of the case. Conversely many unpleasant situations due to misunderstanding of motives or principles may be avoided. It is essential for the surgeon really to know his patient and to give the patient an opportunity in turn to know the surgeon. In this way the patient is put in the proper frame of mind for the operation and *everything* after that is much simpler and easier.

A carefully taken detailed *history* both past and present is of the utmost importance even though it may at times seem rather inconsequential or irrelevant. Occasionally something of great value is discovered and it is this occasional finding that makes it worth while to bend every effort to disclose it. A sensitivity to some common drug a hemophilic tendency or a functional organic defect physically not detectable may be brought to light which would otherwise escape detection and might subsequently mean defeat to the surgeon and disaster to the patient. There is too common a tendency to slur over this safeguard in the apparently simple case and particularly in the emergency case. It is true that there are times when a detailed history should and must be omitted but such instances are actually very rare.

A systematic complete *physical examination* supplemented by such clinical tests—chemical laboratory roentgenographic mechanical—as may be indicated or deemed advisable falls in the same category as the aforementioned history but is if anything even more important. Many extraneous complicating factors are picked up in the course of even the most perfunctory physical examinations (many others would be were the examinations adequately and intelligently performed) which may modify or alter completely the further handling of the case preoperative operative and post-

**operative** Is the surgeon fair to himself or his patient in ignoring or skipping these important preliminaries?

If during the preliminary examinations some complicating factor is discovered this should as a rule and as far as possible be corrected, compensated or planned for *before the operation*. So the weak or failing myocardium should be digitalized, the damaged or insufficient kidneys stimulated, the hyperthyroid patient adequately iodized and the diabetic stabilized. It is here particularly that an understanding cooperation between the surgeon and internist is of the greatest importance and help to the patient. But these conditions will be more fully dealt with elsewhere and cannot be detailed here. Instead only the average *normal* case if there be such a phenomenon is to be considered here.

It is in the young and the aged that the greatest care must be taken to maintain the fluid and alkaline reserve level of the body. A relatively small amount of vomiting such as occurs in a case of acute appendicitis or strangulated hernia may produce appreciable dehydration and incipient if not actual acidosis together with lowering of the chloride value beyond the desired limits. In the average young or middle aged adult this is more difficult of accomplishment. Whenever such a depletion is present it should be corrected by the administration of fluids and alkalis or sugars together with the necessary chlorides. The administration is effected by mouth if the vomiting has ceased and such administration is not otherwise contraindicated by rectum if tolerated and absorbed either in continuous drip or small retention enemas by subcutaneous infusion if the tissues will take it up properly or intravenously which is possibly the best and certainly the quickest and surest way of all either in bulk dosage or continuously by drip through a previously inserted cannula. If sugars are given in any considerable quantity in this way the advisability should be considered of partially balancing it with insulin.

In almost every operative case which is not an emergency with the time for preparation hence limited it is probably wise to augment the glycogen reserve of the liver by administration of sugars for twenty-four

hours or so before the operation. This may be done by mouth or intravenously. It seems particularly valuable in surgical treatment of the gallbladder.

When there is any marked anemia either primary or secondary a transfusion is usually indicated. The operative mortality, the occurrence and degree of postoperative shock and the incidence of postoperative complications seem to bear a more or less direct ratio to the degree of anemia. For this reason one should hesitate to operate on any patient with a hemoglobin content below 60 per cent. If an operation is to be performed which promises to be of considerable magnitude or if there will probably be a considerable loss of blood it is wise to have the patient's blood grouped and matched *before operation* and have a suitable donor available. It is certain that some transfusion may thus be easily averted by taking these extra precautions.

If the patient is jaundiced or has any natural or acquired tendency toward uncontrolled or abnormal bleeding tests for bleeding and clotting time should be made and every effort exerted to bring the values within normal limits.

Finally there are certain routine preparatory measures which apply to virtually all surgical cases. If the stomach, bladder and bowel are empty there will be less difficulty with the anesthetic and less postoperative discomfort. If possible the patient should be given a relatively simple diet of easily digested food the day before operation with nothing but liquids for the last twelve hours and not even these during the four hours before operation. If an emergency operation is to be performed and the patient has eaten within six hours it is usually wise either to induce vomiting or to wash the stomach out before an anesthetic is administered, thus at least to a certain extent removing the danger of aspiration of stomach contents. The anesthesiologist in particular will be grateful. If a cathartic is given it should be one with a quick and thorough action and should be administered at least twenty-four hours beforehand. In any event it is wise to give an enema—warm soap suds is the simplest and as good as any—either the night before or early on the morning of the scheduled operation. This is particularly im-

portant in order to obtain proper retention and absorption when any anesthetic such as avertin is to be administered rectally.

The matter of preoperative sedation especially in the nervous or apprehensive patient depends somewhat on the choice of the anesthetic agent to be employed. Various barbiturates notably luminal sodium luminal amylal sodium amylal nembutal and so on usually in rather large broken doses either by mouth or intravenously are fairly widely used. Their greatest benefit is probably in dulling the sensibility of the patient who is to undergo local regional block paravertebral or intraspinal anesthetic. Morphia or hyoscine or a mixture of the two is sometimes used similarly; the former may be used preparatory to an inhalation anesthesia but many anesthesiologists do not recommend this because of its tendency to induce slow and shallow respirations and to interfere with the pupillary reflexes. Possibly one of the best and safest methods is the administration of a small dose of avertin—not over 80 mg of the drug per kilogram of body weight—as a basal anesthetic. It should be administered while the patient is in bed in his own room about half an hour before operation. In this way the patient usually has no recollection of being taken to the operating room. Other good basal anesthetics that are now available are secenal administered by mouth and pentothal sodium administered intravenously. Lately they have somewhat replaced avertin in popularity.

If an inhalation anesthetic is to be administered and even in other cases a fairly large dose of atropine given hypodermically just before the patient is taken to the operating room is a great help in checking secretions and probably helps to reduce the number of postoperative pulmonary complications. (See section on Atelectasis.)

In the choice of anesthetic many factors need to be considered. Practically every hospital and surgeon has some definite routine or preference in the matter. It is impossible to discuss here the virtues or faults. One anesthetic may be preferable in one case and another under a different set of circumstances. However the *individual patient* should be considered primarily *each time* the choice of anesthetic is made and that

one should be used which seems the *safest* for that particular combination—nervous make up and general condition of the patient type of operation facilities at hand and the ability of the anesthetist.

The last step in the preparation of the patient is the cleansing of the field of operation. There are almost as many variations in this technic as there are hospitals and operators. The object in each case is the same—to render the field of operation as nearly sterile as possible. The most difficult structure to sterilize is the patient's skin and the ideally perfect method which has not as yet been evolved should sterilize not only the surface but the depths of the pores glands and hair follicles; it should not irritate or injure the skin mucous membrane or subcutaneous tissues; it should have lasting qualities of up to three hours; it should not interfere with wound healing and yet it should have sufficient simplicity and adaptability to be universally applicable and generally obtainable. The nearer these criteria are approached the better will be the results as measured in percentage of infected wounds. But here again there are certain underlying principles which apply irrespective of the specific technic. All hair should be removed with an adequate margin by careful shaving. All gross dirt should be removed with soap and warm water and the surface then dried. These two steps may best be done in the patient's room some time before the scheduled operation. The final preparation of the field in the operating room is discussed elsewhere.

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#### MANAGEMENT OF THE SURGICAL DIABETIC PATIENT

The surgeon today is called on to perform many more operations on diabetic patients than formerly. The reasons for the greater frequency of surgical intervention are three: (1) the incidence of diabetes is increasing particularly among persons more than forty years of age; (2) the lives of persons affected with diabetes have been prolonged

as a result of modern methods of controlling the disease so that more of them are living long enough for conditions which require surgical treatment to develop or to be required and (3) many more elective surgical procedures can be carried out safely on diabetic patients than was formerly possible.

To illustrate the importance of this field of surgery from the standpoint of the number of operations performed on diabetic patients as well as to illustrate the low risk that may attend these operations there can be cited a series of 2107 operations of all kinds performed on diabetic patients at the Mayo Clinic in the ten year period from 1930 to 1939 inclusive. In this series there were 111 hospital deaths yielding a hospital mortality rate of 4.8 per cent. The operations included both major and minor procedures as commonly classified more than half of them being major operations such as amputations for gangrene, laparotomy for emergency abdominal conditions and so forth. Considering a specific operation, cholecystectomy for cholecystitis without any other procedure on the bile ducts it was found that among 109 diabetic patients who underwent this operation in the ten year period there were 2 hospital deaths giving a hospital death rate of 1.8 per cent. In 1939 among 703 similar patients who did not have diabetes there were 12 hospital deaths yielding a hospital mortality rate of 1.7 per cent or about the same as that recorded for diabetic patients. It is evident that the mortality of this type of surgical procedure among diabetic patients is not excessive. Diabetes can no longer be considered as ground for denying a patient the benefits of surgery and the decision to operate can now be based upon the same criteria among diabetic patients as among non-diabetic patients.

It is not to be forgotten however that the potential danger of surgical intervention in the presence of diabetes is as great as it ever was. The occurrence of acidosis and coma which often was unavoidable before the discovery of insulin is still a possibility which can be prevented only by the skillful employment of modern methods for maintaining normal metabolism. To this end the complete cooperation of the surgeon, the anesthesiologist, the internist, the dietitian and

the nursing staff is of the utmost importance. The patient should be subjected to a minimum of operative trauma, the period of anesthetic should be short and the preoperative and postoperative management of the diabetes should be precise. These recommendations apply to mild as well as to severe diabetes; for mild diabetes temporarily may become severe subsequent to anesthesia and operation.

**Preoperative Preparation.**—Unless immediate operation is necessary the patient should be observed in the hospital for several days in order to secure the most favorable conditions. This period of observation is of particular importance when the diabetes is severe enough to necessitate the use of insulin. For two or three days before going to the operating room the patient should be completely free from acidosis; glycosuria should be well controlled and there should be adequate reserves of glycogen, water and electrolytes. The diet should be weighed and usually should contain 200 Gm. of carbohydrate. Under certain special conditions, notably surgical operation on the biliary tract and on the thyroid gland in the presence of hyperthyroidism, an even higher carbohydrate intake may be desirable. The caloric value of the diet of patients with hyperthyroidism should also be increased in proportion to the elevation of the basal metabolic rate. The qualitative character of the diet can be modified as necessary for patients who have lesions of the gastrointestinal tract provided its caloric and carbohydrate values are maintained at the desired levels. Sufficient insulin is used to maintain the urine free of sugar or nearly so. Other special aspects of preoperative preparation including medications are planned with regard to the general condition of the patient rather than to the presence of diabetes. On the morning of operation breakfast is withheld and a dose of protamine zinc insulin equal to approximately half of the total daily requirement of insulin is given.

**Emergency Surgical Procedures.**—Operations performed in the presence of diabetic acidosis or coma are done at greatly increased risk but to delay urgent surgical intervention may be even more perilous. This is particularly true when there are present



inflammatory lesions such as rapidly spreading gangrene of an extremity with infection acute appendicitis pelvic abscess mastoiditis or some other acute inflammatory process which if neglected may threaten the life of the patient as well as interfere with control of the diabetes. In such instances a single injection of 20 to 100 units of unmodified insulin depending on the degree of acidosis should be given. 1 liter or more of physiologic saline solution should be administered intravenously and operation should then be performed without further delay.

**Diagnosis of Abdominal Lesions**—The diagnosis of acute abdominal lesions especially appendicitis may present serious difficulty in the presence of uncontrolled diabetes. The patient who has diabetic acidosis occasionally presents signs and symptoms closely resembling those resulting from lesions that require immediate surgical operation. Thus nausea and vomiting abdominal pain and tenderness rapid pulse leukocytosis and even fever may be associated with acidosis in the absence of any demonstrable abdominal lesion. Leukocyte counts as high as 60 000 in each cubic millimeter of blood have been observed during diabetic coma and counts of from 15 000 to 20 000 are not at all uncommon. Fever if present is due to infection or dehydration but the infection may be in the respiratory tract and not in the abdomen. On the other hand an acute inflammatory process in the abdomen may be associated with and responsible for the existing acidosis.

A carefully elicited history is of great importance in arriving at a diagnosis in such cases. Abdominal pain preceding the onset of other symptoms speaks for a surgical emergency particularly if the onset of the pain is acute whereas a gradual onset of symptoms with polyuria polydipsia and nausea preceding the abdominal pain probably means acidosis. Generalization of the findings on abdominal examination speaks for acidosis while localization usually indicates a surgical lesion. If pain persists after two to three hours of treatment of the acidosis surgical exploration of the abdomen should be carried out.

**Anesthesia**—Prior to the advent of insulin the choice of anesthesia was a matter of great importance. Inasmuch as there are

now good means at hand for the control of the metabolic disturbances produced by anesthesia provided the physician anticipates or recognizes them the patient can for the most part be placed under the kind of anesthesia which the surgeon ordinarily would choose for a non diabetic person undergoing the same type of operation. An anesthetic agent should be used which will produce a minimum of postoperative nausea and vomiting. From the standpoint of their effects on the carbohydrate metabolism of the diabetic patient the order of preference of anesthetic methods is approximately as follows: (1) local or block (2) spinal and (3) general. The order of preference of general anesthetic agents is approximately: (1) cyclopropane and oxygen (2) ethylene and oxygen (3) nitrous oxide and oxygen (4) intravenous pentothal or evipal and (5) ether. Local anesthesia and block anesthesia if they involve the use of considerable quantities of a vasoconstricting agent such as epinephrine may have an undesirable effect on diabetic metabolism by stimulating hepatic glycogenolysis. Obviously the same order of preference may not hold true from the standpoint of surgical indications. Ether for example causes loss of glycogen from the liver and acidosis but it may still be preferred when its use can be expected to shorten the time of operation and to reduce surgical trauma by providing better relaxation.

**Postoperative Treatment**—After operation the diabetic patient should be returned to a medical ward and the management of the diabetes should be the responsibility of a medical service. The essential features of treatment of diabetic patients during the first few days after an operation are sufficient fluids and electrolytes liberal amounts of carbohydrate and adequate insulin. Postoperative ketosis is common even among non-diabetic persons and when the patient is diabetic special precautions are necessary to prevent its occurrence. A daily intake of at least 120 Gm of carbohydrate should be maintained and the utilization of most of this amount should be assured by the proper administration of insulin. Slow intravenous injection of solutions containing 0.9 per cent of sodium chloride and 5 per cent of glucose will provide a satisfactory supply of fluid

which primary amputation was made through the leg secondary operation was necessary in only 4 cases and the ultimate outcome was fatal in only 7 per cent. In a more recent series of 66 primary major amputations among 61 patients Macey and Bickel reported a mortality rate of 10.6 per cent based on the number of primary amputations or 11.4 per cent based on the

diabetic patients with arteriosclerosis will burn and blister at temperatures far below those tolerated by patients who have a normal circulation. Within twenty-four hours after these measures are started the infection usually begins to subside or gives clear evidence of advancing. If it subsides treatment is continued until it is controlled fully and the decision then is made as to whether the

TABLE 15.—RESULTS OF TREATMENT IN CASES OF DIABETIC GANGRENE OF TOES AND FEET\*

	Patients †	Successful	Deaths	Mortality rate per cent
Treated medically	69	43	16	23.0
Treated surgically	86	71	8	9.3
Primary amputation below ankle (higher amputation later in 5 cases)	15	7	3	20.0
Primary amputation above ankle (higher amputation later in 4 cases)	71	62	5	7.0

\* Data furnished by Allan and Kintner.

† All these patients had necrosis of tissue of considerable degree perforating ulcers and other sores were not included.

number of patients. Once amputation is decided on it should be performed below the knee if the pulsation is good in the popliteal artery, but above the knee if the pulsation is inadequate. McWhittrick and Root wisely advised against the use of a tourniquet in these amputations for pressure which is sufficient to shut off the blood stream in a calcified vessel may result in fresh thrombosis and subsequent occlusion. Also if a tourniquet is not used the amount of bleeding from an exploratory incision permits the surgeon to estimate the adequacy of the blood supply at the proposed level of amputation so that he can make the amputation higher if necessary.

The medical treatment in cases of infected extremities with or without gangrene includes absolute rest in bed, rigid control of glycosuria, application of warm moist dressings saturated with a mixture of equal parts of 50 per cent alcohol and a saturated solution of boric acid and chemotherapy with the sulfonamide drugs. The foot is very slightly elevated above the horizontal. The dressings should extend well beyond the region of infection and their temperature should not exceed 105° F. (40.5° C), for the skin of

degree of accompanying gangrene or the degree of circulatory impairment justifies amputation. If the infection has progressed after twenty-four hours of treatment amputation usually is recommended. If redness and swelling extend beyond the ankle immediate amputation is urged. A gangrenous lesion which is dry and not grossly infected is covered with a dry dressing and protected against mechanical injury.

Measures for improving the collateral circulation in the feet should be used if it is decided that amputation can be delayed and if the area of gangrene is small enough so that there is reasonable hope of saving the extremity. These measures include postural exercises of the Buerger type which can be carried out by the patient himself or by means of a bed of the Sanders type and measures for producing vasodilatation such as contrast baths, the employment of intermittent venous occlusion, the ingestion of alcohol and an environmental temperature of about 86° F. (30° C). The use of apparatus for producing alternate positive and negative pressure on an extremity is to be avoided as it is rarely beneficial and may result in extension of infection.

**Ulcers and Other Sores**—Lesions of the feet that are not accompanied by gross impairment of circulation are caused as a rule by injury and infection. They include infected corns and calluses, perforating ulcers, osteomyelitis, burns, frostbite, varicose ulcers and septic abrasions. The perforating ulcers and indeed many of the indolent infectious conditions of the feet in diabetes may in part be dependent on the presence of peripheral neuritis. Frequently the feet are abnormally insensitive and complaints of numbness and of aching pains at night are common. The insensitivity of such feet often leads to inadvertent injury. Woltman and Wilder have considered one reason for the neuritis of diabetes to be interference with the blood supply of the nerves. Osteomyelitis should be suspected in every localized infection of more than two weeks' duration in any part of a toe or foot (McKuttrick and Root). The diagnosis is made roentgenologically or by encountering rough bone with a probe on exploration. Amputation of a toe because of osteomyelitis when there is good pulsation in the dorsalis pedis and the posterior tibial arteries is a relatively safe procedure.

Often much needless suffering results from unnecessary delay in the treatment of minor injuries and infections of the feet. Diabetic patients should learn to take all abrasions seriously, to stay off their feet and to apply immediately a non-irritating antiseptic such as a mixture of boric acid and alcohol. Clean socks, well fitting shoes and avoidance of injury are important prophylactic measures.

The conservative treatment of chronic lesions of the feet is essentially the same as the medical treatment described in the section on gangrene. Thick calluses should be trimmed with a razor or filed down. The local application of sulfonamide compounds in powder form to chronic ulcers is helpful in some instances. The measures already mentioned for increasing the peripheral blood flow should be used if this is deficient. Extreme caution should be used in the application of heat or roentgen treatment to the feet of diabetic patients. Under no circumstances should hot water bottles or any other heating device which is not thermostatically controlled be applied below the knees. The temperature of solutions used in the prepara-

tion of wet dressings should be tested with a thermometer and should not exceed 103° F (40.5° C). Strict adherence to these rules will save many legs and obviate embarrassing medicolegal complications.

**Fractures in Diabetes**—It is generally recognized that diabetes is intensified and the requirement for insulin increased by infection by hyperthyroidism and by anesthesia and operation, but it is not so well known that fractures may have this effect to a very marked degree. The following brief reports of cases provide illustrations. In one case a woman aged sixty-six years who had been known to have diabetes for five years sustained fractures of the surgical neck of the right humerus and of the right hip. Whereas the urine had previously been free of sugar without insulin for thirty days after the accident the patient required from 25 to 40 units of insulin daily. Another woman, sixty years old who had had diabetes for four years sustained an intertrochanteric fracture of the femur. Before the fracture the insulin requirement had been 70 units daily; afterward a daily dose of 105 units did not completely prevent glycosuria. In another case a man forty years old sustained multiple fractures in an automobile accident. There had been no previous history of diabetes but immediately after the accident intense glycosuria developed that required insulin for its control. On the one hundred and sixth day after admission a glucose tolerance test was carried out with practically normal results. The mechanisms by which fractures aggravate diabetes are not clear.

**Carbuncles**—This complication is nearly always preventable by cleanliness and proper attention to the control of glycosuria. Carbuncle has occurred in many cases of obese, uncleanly patients who have given little care to their mild diabetes and who have made the mistake of squeezing or pricking a pimple or boil. Since boils are sometimes due to infection from barbers' razors and since carbuncles may follow boils it is wise for the diabetic patient not to permit his neck to be shaved at a barber shop.

Deaths from carbuncle occur for the most part when treatment is delayed. In such cases the lesion may attain a large size and the fatal issue may be due to bacteremia. Early treatment of both the carbuncle and

the diabetes usually leads to a favorable outcome

There are wide differences of opinion and method in the treatment of carbuncle associated with diabetes but in general conservative measures seem to give the best results. The patient is kept at rest in bed and glycosuria is controlled rigidly. Thick gauze and cotton dressings saturated with a solution of boric acid and alcohol are applied to the lesion and kept warm. While no chemotherapeutic agent can be expected to penetrate to the central region of destruction of tissue in a carbuncle early treatment with the sulfonamide compounds seems to be of real value in preventing further invasion of tissue and bacteremia. Sulfathiazole is the most logical of these agents because of its relatively low toxicity and its slight tendency to produce nausea and vomiting and because of its effectiveness against the staphylococcus which is the usual infecting organism in carbuncle. While chief reliance should be placed on oral administration local application of the compound in powder form also seems worth while. Treatment with roentgen rays may hasten localization of the infection and lessen pain.

Incision of a carbuncle if it is necessary at all is best done only after central necrosis has resulted in the formation of a well localized pocket of pus. Frequently the only intervention which is necessary to establish drainage is the gentle introduction and opening of a pair of sterile artery forceps. Occasionally the destruction of skin necessitates skin grafting but this is not the rule. A wide crucial incision extending through the zone of induration probably has led to extension of infection and bacteremia in some cases.

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TRAUMATIC SHOCK

The word shock is applied to practically all types of acute peripheral circulatory failure regardless of cause or of multiplicity of causes. The grouping together under one term of a variety of conditions some of which have little relationship to one another, has made definition unsatisfactory and classification difficult. Attempts to substitute more exact terminology have resulted in failure. Just as there are many causes of fever so there are many causes of shock or acute peripheral circulatory failure. At least partial clarification would result from the use of descriptive terms in association with the word shock, such as shock following burns, shock following trauma to extremities, shock following hemorrhage and shock associated with peritonitis. It is important to remember that a number of different factors may be jointly responsible for the development of shock.

Many theories have been advanced in an effort to explain shock. The statements in the preceding paragraph demonstrate why no one of these has been accepted to the exclusion of all others. The three most generally accepted theories at the present time are (1) the theory of the regional loss of blood and fluid, (2) the toxic theory which includes the effects of bacterial infection and (3) the theory of the effects of trauma on the nervous system. It is the writer's opinion that the regional loss of blood and fluid at and near the sites of injury is the most frequent initiating cause of traumatic shock.

An attempt has been made to classify shock or acute peripheral circulatory failure from a physiological viewpoint. The terms which have been used to designate the different types are hematogenic, neurogenic

and vasogenic shock. These will be considered in order.

**1 Hematogenic Shock**—Hematogenic shock is the typical traumatic secondary or wound shock in which the important alteration is the reduction in blood volume. The output of the heart declines early but the arterial pressure may remain at or near a normal level as a result of compensatory vasoconstriction.

Since it is with this type of shock that this discussion is particularly concerned a statement of the present status of the problem is indicated. Increased confidence in the results of experimental observations has resulted from the finding of a close correspondence in circulatory changes in shock in man and in animals. It has been shown that a reduction in the volume of circulating blood is the most important factor in the initiation of shock. This reduction is due to the loss of blood or fluid at the site of injury, whether mechanical or thermal, and with the possible exception of the late stages of traumatic shock, there is no notable increase in capillary permeability in non-traumatized regions of the body. As shock progresses the cardiac output continues to decrease even though there may be no further reduction in the volume of circulating blood. After a critical point has been passed in diminishing cardiac output, lowered blood pressure and reduced blood volume, then progressive tissue anoxia leads to metabolic changes and to damage to certain organs such as the heart, brain and adrenals. This damage if prolonged constitutes the state termed *irreversible shock*.

While the reduction in blood volume is usually the main factor in the production of shock in injured persons, there is evidence that trauma to tissues adds considerably to the severity of the condition and in some instances may be the dominant factor. It is probable that products of tissue destruction enter the blood stream when the circulation is reestablished through partly devitalized tissues such as may be encountered in burns and in crushing injuries. In some patients who recover from the oligemic (reduced blood volume) shock of burns an illness of variable severity develops later. It seems probable that unknown factors in addition to regional loss of plasma are responsible.

In crushing and compression injuries the satisfactory treatment of the early oligemic state may be followed some days later by development of renal failure. It is likely that the diffusible constituents of the injured tissues are responsible for the damage to the kidneys. Extensive bacterial infection when present in association with wounds and burns contributes to the development of shock. Severe injuries, particularly of the long bones, are followed infrequently by partial blocking of the pulmonary capillaries by globules of fat and by an unusual type of shock. In other words, in addition to the reduction in blood volume which is usually due to the regional loss of whole blood or plasma, there are these factors and others not mentioned which may play a part in the development of traumatic or hematogenic shock.

In addition to the variations in the underlying mechanisms which have been enumerated, it must be borne in mind that injuries to various parts of the body, such as the head, chest and extremities, may each have characteristic features.

**2 Neurogenic Shock**—Neurogenic shock refers to the condition in which vasodilatation occurs as a result of diminished constrictor tone. The blood pressure declines first and the reduction in cardiac output is subsequent. This type of shock may be due to direct action on the nervous system as by spinal anesthesia or it may be reflex in origin as from a severe blow on the abdomen. A decline in blood pressure of this nature is of less grave significance than that encountered in hematogenic shock, since it is not associated with such a serious decline in the blood volume. The observations of Phemister and others indicate that neurogenic elements are rarely of great importance in the pathogenesis of traumatic shock.

Considerable interest has been shown recently in a condition known as vasovagal collapse. It has been noted most often in blood donors, a small percentage of whom exhibit a slow pulse and profound collapse following removal of a pint or less of blood. It has been shown that this type of collapse results from sudden arteriolar dilatation and is apparently identical in mechanism with an ordinary faint.

**3 Vasogenic Shock**—Vasogenic shock

is the type in which vascular dilatation is brought about by direct action of substances on the vessel walls. Histamine probably produces its effects in this manner. Part of the effects of the passage of irritating intestinal juices into the peritoneal cavity is explainable on this basis.

It should be emphasized again that shock frequently represents a combination of several different types of disturbances.

**Clinical Aspects**—The clinical picture of fully developed traumatic shock is readily recognizable. Apathy, ashen cyanosis, clammy skin and low blood pressure are perhaps the outstanding characteristics. There is usually complaint of thirst. Nausea and vomiting are frequently present. Pain is not often a major complaint. The pulse rate is usually but not always elevated. There is generally a marked decrease in the volume of the pulse. The veins are not prominent. Alterations in respiration are much less obvious than those in the circulatory system. The urinary output is reduced. Hemoconcentration may or may not be present.

Difficulty arises in the recognition of early or incipient shock. This is unfortunate because shock can usually be prevented if early treatment is instituted. It has been stated that vasoconstriction functions to prevent a decline in blood pressure in incipient traumatic shock and hence alterations in blood pressure do not serve as an early criterion. Changes in the pulse rate may be misleading. Hemoconcentration is usually observed in association with burns, crush injuries and peritonitis but may not occur under other conditions. The response of the arterial pressure to an alteration of the position of the patient may serve as an early indication of shock.

Since there is no invariable early criterion of incipient traumatic shock, it is wise to assume that shock is impending and to institute treatment whenever the seriousness of the injury suggests that there has been extensive loss of blood or a reduction in volume of circulating blood from other causes. Examples of conditions which indicate that shock may be impending include blood-soaked clothing, signs of internal hemorrhage, extensive crushed areas, burns of large areas, lengthy operative procedures, severe

dehydration and prolonged exposure to cold. Inadequate nutrition, dehydration, exposure to excessive heat or cold, loss of sleep, physical and emotional exhaustion and various acute and chronic illnesses predispose to the development of shock.

**Prevention and Treatment**—In operations of election a great deal can be done to prevent shock. If dehydration exists the body fluids should be restored to normal. Drastic purgatives should not be given since they result in dehydration. Glycogen reserves in liver and muscle should be restored. Nervousness and fright should be overcome by sedatives and reassurance.

**Hemostasis**—Hemostasis should be as effective as possible. The quantity of blood that is lost during operative procedures is usually greater than the estimated amount. A tourniquet should not be used for the control of bleeding if other methods, including pressure dressings, will suffice. If a tourniquet is required, it should be released from time to time unless this procedure results in a prohibitive loss of blood. Cooling of the part distal to the tourniquet results in a lessening of the damage to tissues as a result of the ischemia.

**Morphine**—Morphine should be administered for the relief of severe pain but should not be given routinely. The majority of patients in a condition of shock do not complain of pain. Morphine causes nausea and vomiting in some patients and hence adds to the difficulty of preventing or treating dehydration. If morphine is given subcutaneously to a person in shock, it is well to remember that it may not be absorbed until the state of the circulation is improved. An additional injection then may result in overdosage.

**Splinting**—The immediate careful splinting of broken bones is of great importance. This measure reduces pain and lessens further damage to the soft tissues in the region of the fracture.

**Posture**—The posture of the patient is important. The head down or shock position usually results in subjective improvement. The head up position is often accompanied by a decline in blood pressure.

**Temperature**—In the past there has been too great emphasis on the desirability of causing elevation of the temperature of the patient in a state of shock. The temperature

of the extremities is decreased in traumatic shock because of the vasoconstriction associated with the lessened blood volume and because blood is diverted to more vital structures. If in the presence of an inadequate blood volume the extremities are surrounded by hot water bottles vasoconstriction is replaced by vasodilatation. Furthermore the loss of fluid by sweating results in further dehydration. An attempt usually should be made to conserve body heat rather than to add warmth artificially. If the patient has been seriously chilled he should be warmed slowly and cautiously. Plasma or blood should be available to be given promptly if the blood pressure falls during or soon after warming.

**Adrenal Cortical Extract**—Adrenal cortical extract has not been shown to have any effect on acute traumatic shock in man or animals in the absence of adrenal insufficiency.

**Oxygen**—Inhalation of oxygen in the treatment of traumatic shock has been disappointing. While in some instances the venous blood shows a substantial increase in oxygen content, usually no definite benefit is observed. When injury has led to interference with the respiratory oxygen uptake in wounds of the chest or in pulmonary edema from various causes it is obvious that oxygen therapy is indicated.

**Vasoconstrictor Drugs**—Vasoconstrictor drugs are rarely indicated in the treatment of traumatic shock since vasoconstriction is already present. The ideal to be sought is an increase in the blood volume rather than simply an elevation of the arterial pressure. If fluids are not available for replacement it is possible that one of the vasoconstrictor drugs may exert a temporary beneficial effect.

**Transfusions**—Just as the most important alteration in traumatic shock is the decrease in the blood volume so the most important form of therapy consists of methods which are directed to a return of the blood volume to normal. In some instances the major loss of fluid consists of whole blood whereas in others it is plasma. In the past the chief mistake has been an underestimation of the degree of fluid loss and of the quantity of fluid that is required to return the blood volume to normal. It has not been sufficiently

appreciated that the return of the arterial pressure to normal does not mean that the blood volume is similarly restored. Some patients may lose 25 per cent or more of the total blood volume without a significant reduction in the systolic pressure and it follows that the arterial pressure may return to normal after transfusion before the blood volume is fully restored. A patient who is in a state of severe shock as a result of hemorrhage usually requires a transfusion of 2 000 to 2 500 cc of blood.

One should not delay transfusions after hemorrhage until hemodilution occurs. The circulating hemoglobin is seldom reduced more than 15 per cent during the first several hours after hemorrhage regardless of its severity. The passage of fluids from the tissue spaces to the blood stream operates slowly in man. In other words hemoglobin levels during the early hours after injury do not serve as an adequate index of the severity of the blood loss.

In the absence of evidence of blast injury and pulmonary irritation the first 2 pints of blood or a blood derivative may be given as rapidly as 1 pint of isotonic fluid in ten minutes. Additional injections should be given more slowly.

The administration of blood plasma or serum is the ideal intravenous treatment for burns since it is mainly this part of the blood which is lost. Anemia may become a troublesome problem several days after the injury but is not in the beginning. If albumin concentrate is employed it should preferably be diluted with salt solution. The quantity of isotonic salt solution or of glucose solution which is injected intravenously should not exceed that of the blood or blood derivative which is used. Fluids should be given by other routes if they are retained and absorbed. Sodium lactate and salt solution by mouth and intravenously form valuable adjuvants in the treatment of burns but should not be used to the exclusion of blood derivatives such as plasma. There are a number of reasons why the use of sodium salts is beneficial. Recent work indicates that gelatin solution is a moderately effective substitute for blood plasma.

Since the loss of plasma during the early hours following a burn is so rapid it is more economical of plasma to space the injections

over a thirty six hour period than to give most of the solution during the initial period. Harkins and others have made a number of suggestions regarding methods for determining the requirements for plasma. One technique consists in giving 100 cc of plasma for every point the hematocrit reading exceeds the normal level of 45. If hypoproteinemia exists a larger quantity is advisable. An alternative suggestion is that 50 cc of plasma should be given for every point the hemoglobin reading is above the normal of 100. Still another method consists in gauging the therapy according to the area of body surface burned.

**Renal Failure**—In addition to preventing and treating shock which may ensue shortly after *crush injuries* one should employ measures to prevent delayed renal failure. The most important step is establishment and maintenance of an alkaline diuresis by the administration of sodium bicarbonate. Experience in England indicates that if possible fluid and alkali should be given to patients before release from compression.

**Anesthesia**—General anesthesia may add considerably to the severity of shock. It should be as light and as short in duration as possible. Ether by inhalation with a high concentration of oxygen, cyclopropane and ethylene are probably the safest agents when relaxation is needed. Local anesthesia should be used when it meets the requirements.

**Operation**—An attempt should be made to get the patient into a stabilized state before an operation is undertaken. This means among other things that operation must be delayed if alteration of the position of the patient has been accompanied by a fall in blood pressure. On the other hand operation should not be postponed any longer than is necessary. This is particularly important if there is continuing bleeding which cannot otherwise be arrested. Early operation is also important in preventing infection. Prior to the beginning of the procedure a needle should be placed in an accessible vein and blood should be administered throughout the operating period which preferably should not be prolonged beyond one hour.

Several points merit special emphasis. Much remains to be learned about traumatic shock, but it has been shown that in the ma-

jority of cases shock can be prevented or treated successfully by the early and copious use of transfusions of whole blood and blood derivatives. An attempt should be made to use in replacement therapy a solution of approximately the same composition as that which has been lost from the blood stream. The ready availability of plasma has resulted in its use in many instances in which whole blood is needed. Only red blood corpuscles can transport oxygen effectively. Blood or its derivatives should be administered according to the nature and extent of the injury and the blood loss. One should not delay treatment until the blood pressure declines or hemoconcentration or hemodilution occurs when it is obvious that the blood volume is decreased. Shock in association with an operation can usually be prevented by the administration of adequate quantities of blood during the procedure. This is expected and one is less apt to procrastinate if a needle is placed in an accessible vein prior to the beginning of an operation. The patient suffers as the result of the pride of the surgeon who is of the opinion that little blood is lost in procedures of the magnitude of thoracoplasty or pneumonectomy. A decline in blood pressure due to hemorrhage and associated with vasoconstriction requires rapid transfusion. A fall in blood pressure associated with vasodilatation is of less grave significance and the pressure will usually return to normal if manipulation is terminated. When in doubt transfusions should be administered. Furthermore care should be taken not to overheat the patient during or following operation.

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## ACIDOSIS AND ALKALOSIS

Acidosis and alkalosis are almost always associated with an altered water exchange. Abnormal losses of fluid by vomiting, diarrhea, drainage from intestinal and biliary fistulas or massive exudation from burned surfaces will withdraw water and the materials held in solution by it from the body until serious depletion of these substances may result. The loss is not only from the blood plasma but also from the other body fluids as water and materials are taken from them by way of the blood in response to the abnormal demand.



In order to understand the processes leading to acidosis and alkalosis a knowledge of the acid base composition of normal blood plasma is necessary and is shown in figure 762 (Gamble). For the sake of brevity only a few of the related facts can be emphasized. The predominance of sodium as the chief base and chloride ions as the chief acid radicals is important. It should be understood that the retention of blood plasma and other body fluids is mainly determined by the ratio of carbonic acid to bicarbonate still present in these fluids. This ratio is practically always such that blood plasma is alkaline but the degree of alkalinity may vary. The other inorganic substances present are salts of strong acids with strong bases and are therefore neutral salts. Another point of importance is that the number of acid radicals always equals the number of basic radicals. Adjustability is brought about mainly by the ease with which the bicarbonate ion can vary to fit the need being increased by formation from free carbonic acid or eliminated by again becoming free carbonic acid and being thus removed through the lungs. As the concentration of total base and of the stronger acid radicals may change importantly under abnormal circumstances the amount of bicarbonate ions present may vary from that producing an increased alkalinity of the blood plasma to the point of acidosis down to a decreased alkalinity described as acidosis.

**Alkalosis.**—Excessive vomiting is the most common cause of alkalosis. Vomitus contains an excess of chloride ions over sodium and the continuous withdrawal of these materials from the blood plasma in unequal portions results in a much larger deficit of chloride ions than of sodium. Bicarbonate ions are automatically increased to replace the lost chloride ions and thus cover the relative excess of sodium. If the degree of alkalosis produced is severe enough tremor of the facial muscles, numbness of the extremities, a positive Chvostek's sign and a carpopedal spasm may occur. It is certainly inadvisable to wait for the development of these signs in order to make the diagnosis of alkalosis. Whenever excessive vomiting occurs the condition should be considered and its presence and degree determined by a study of the chlorides of the

blood and the plasma carbon dioxide-combining power. The blood non-protein nitrogen should also be determined to show the possible retention of waste products ordinarily excreted by the kidneys but now retained because the water usually available for renal function is lost in the vomitus.

The treatment of alkalosis consists of supplying sodium chloride and an abundance of water. The correction of the condition should be followed by studies of the blood chemistry. The salt can well be given as Ringer's or physiologic saline solution. Although these solutions supply sodium and chloride ions in

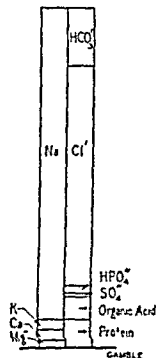


Fig. 762.—The acid base composition of normal blood plasma

equal amounts and the patient has lost an excess of the latter the kidneys with a good supply of water can be relied on to excrete the surplus of sodium. The saline solution tends to be retained and is thus excellent for returning the lost electrolytes and water to the depleted tissues but for exactly that reason it is not ideal for furnishing an immediate excess of water. This can best be done by giving also a 5 per cent solution of glucose in distilled water. The glucose is rapidly oxidized and the water is left available for all physiologic purposes.

**Acidosis.**—The production of acidosis by an abnormal loss of intestinal secretions is

much less common among surgical patients than the production of alkalosis by vomiting. Intestinal secretions are alkaline and in contrast to gastric juice have a greater proportion of sodium ions than of chloride ions. In severe diarrhea or copious drainage from an intestinal or biliary fistula the continuous withdrawal of these electrolytes in unequal amounts from the blood plasma may result in a relative increase in chloride ions. A consequent reduction in bicarbonate occurs with the plasma reaction changing in the direction of acidity. The treatment of this type of acidosis is the same as that given for alkalosis. In this instance more sodium ions are needed than chloride ions but if salt is given with an abundance of water the kidneys will deal separately with these radicals and excrete the surplus. The extent of the acidosis and its correction should be determined by the same blood chemistry studies used for alkalosis.

**Ketosis.**—The accumulation of incompletely oxidized fatty acids in the form of beta-oxibutyric acid, diacetic acid and acetone is known as ketosis and is the most common cause of acidosis. These fatty acids displace bicarbonate ions with a consequent blood plasma reaction tending toward acidity. A reduction in the concentration of free carbonic acid in the plasma would help to correct this condition. An effort in this direction is made by the respiratory mechanism producing hyperpnea. This abnormal breathing, an acetone odor on the breath and ketone bodies in the urine are the clinical signs of ketosis. Ketosis develops when carbohydrate utilization is below metabolic needs as in starvation or diabetes mellitus. Immediate therapy consists in supplying glucose; insulin also is administered in the case of diabetes. The ketone acids are eliminated by proper oxidation processes and when there is an adequate supply of water by excretion through the kidneys. Since the fatty acids are neutralized in the plasma by base (sodium) and excreted by the kidneys with base, in severe ketosis there may be an important drainage of sodium from the body. In such cases the assistance of alkali therapy appears to be well founded.

While the foregoing brief discussions of alkalosis and ketosis have been offered sep-

arately, conditions may arise in which factors of both may be present at the same time. Extensive vomiting may deplete the blood chlorides and also by restricting the food intake may lower the carbohydrate metabolism with the resulting formation of ketone acids and acetone. Thus it is not uncommon to find patients with some degree of both alkalosis and ketosis. A plentiful supply of water and glucose and salt solution given in quantities checked by blood chemistry studies readily corrects the condition.

There are other causes of alkalosis and acidosis such as from therapeutic measures or in advanced renal disease but they are far less frequent than the instances presented.

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#### WATER AND ELECTROLYTE BALANCE

Water is of greater importance to the human organism than any other substance. It normally comprises 65 per cent of the total body weight and is fundamentally involved in every physiologic process. After entering the body through the gastrointestinal tract, water passes to three compartments: the blood, the interstitial spaces and the cells. While there is no great reserve of any of these three, some water can be mobilized from the interstitial spaces. In health the normal balance is maintained in response to hunger and thirst. In sickness, because of the disease or the operation, the patient often cannot respond to these stimuli and the fluid intake must be provided for by the surgeon. A knowledge of the water requirements in health and disease is therefore fundamentally important.

There are two main sources of water available to the organism and three means of excretion as follows:

*Intake water*

- 1 Water drunk
- 2 Food, Diet or body substance
  - a Water content
  - b Water of oxidation

*Excreted water*

- 1 Water of urine
- 2 Water of stool
- 3 Water vaporized

The fluid intake varies from day to day with conditions of work, heat and humidity, but the amount usually ranges from 800 to 2000 cc daily. The water available from food comes from two sources, no matter whether the food used is that of the diet or of the person's own body substance. Usually the water content plus the water formed by the oxidation of food yields an amount of water equal to about nine tenths of the total weight of the food eaten. In this way the general hospital diet furnishes about 1200 cc of water a day and the semi solid food of the soft diet about 500 cc.

Important water excretions are concerned with two physiologic processes, namely, the dissipation of body heat by the vaporization of water from the skin and lungs and the excretion of waste materials in solution through the kidneys. The loss of water in the stool is rarely more than 200 cc daily, for although from 7 to 10 liters of fluid is poured into the upper part of the gastro intestinal tract each twenty four hours most of it is reabsorbed lower down.

The vaporization of water from the skin and lungs is an important part of the mechanism for the regulation of body temperature. It is continuous and relatively little affected by the supply of water available. Newburgh and his associates have shown that for a normal adult going about routine activities without sweating, vaporization accounts for approximately 25 per cent of the total heat dissipated and uses from 1000 to 1500 cc of water daily. With the sweating of hard physical work or of high temperatures and humidities up to 100 per cent of the body heat may be dispersed by this process and several liters of water may be so used daily.

In contrast to the vaporizing process the output of urine is markedly affected by the amount of water available, the waste materials presented to the kidneys being excreted

with the water left after the other processes have been cared for. There is a minimum of water needed, however, and even for a person with normal kidneys this should never be less than 500 cc daily. A volume of urine appreciably below this amount is insufficient and generally is accompanied by retention of waste materials, as shown by an increased non protein nitrogen content of the blood. It is better to have more than the minimum urinary output. With a good supply of water available from fluids drunk and food eaten the balance between intake and output will be maintained by the kidneys, the surplus water being used to facilitate the excretion of waste materials. On this basis a good water balance is shown by a good urinary output and a small volume of urine of high specific gravity, nearly always means there is insufficient water.

It is common knowledge that on the day of a major operation a low intake of fluid and food in most cases decreases the supply of water available. The exchange for the day is further interfered with by such abnormal fluid losses as blood, vomitus and the increased sweating induced by some anesthetics by the warm operating room and by the increased coverings of the postoperative ether bed. The total fluid thus lost may well exceed 3 liters and the output of urine for the operative day may be markedly diminished or absent. The practice of giving some fluid parenterally on the day of the operation, particularly to the patient undergoing a long serious procedure, is well founded.

Not infrequently the ingestion of fluid is interfered with for several days after operation or the disease alone may make it necessary for the surgeon to provide water. A knowledge of the daily water requirements of the surgical patient is then essential. With nothing taken by mouth the only water available without dehydrating the patient is that coming from the oxidation of body protein, fat and carbohydrate for energy. This usually yields less than 500 cc of water per day and for practical purposes this small amount can be disregarded. The surgeon should give sufficient water to provide for the daily excretions.

As in the healthy adult the excretion of water by the surgical patient is mainly for

two functions (1) the carrying away of waste materials through the kidneys and (2) the dissipation of body heat. Since the vaporizing process seems to have first claim on available water and since the kidneys function largely with what is left, the problem is to know what loss by vaporization amounts to and then give an additional amount of water for the kidneys.

An adult patient convalescing smoothly from a major operation vaporizes from 1000 to 1500 cc of water daily. With increases in heat production as from hyperthyroidism or fever from 1500 to 2500 cc may be vaporized daily even under comfortable environmental conditions. A safe estimate is 2 liters per day.

The amount of water for the urine is the next question. It has been stated that 500 cc of urine per day is the absolute minimum for a person with normal kidneys. Twice this amount, 1000 cc, enables the kidneys to carry out their function without having to work at maximum capacity and is a desirable volume for most surgical patients. For the patient with sepsis, 1500 cc of urine per day is recommended.

To summarize, the daily water requirements of surgical patients should be considered as follows:

Water for vaporization  
Water for urine

Uncomplicated  
case

1000-1500 cc.  
1000 cc.  
2000-2500 cc.

Complicated  
case (sepsis)

2000 cc  
1500 cc  
3500 cc

To these volumes required for normal excretions an additional amount because of an abnormal loss of fluid as by vomiting or drainage from an intestinal or biliary fistula, frequently must be added. If these losses are not taken into consideration, an apparently sufficient amount of water is actually insufficient, and a low urinary output of high specific gravity results. There are many causes of oliguria and anuria, but no other should be considered until the total water exchange including the abnormal losses for the few previous days has been checked over and dehydration as the etiologic factor has been eliminated. Generally, insufficient urine means insufficient water.

The patient who enters the hospital in a dehydrated condition presents another prob-

lem in water balance. An amount of fluid sufficient to provide for the daily excretions is not enough; an additional amount is necessary to make up for the fluid previously lost. Studies have shown that the common clinical signs of dehydration are present when a patient *deprived of water* has lost an amount of body water equal to 6 per cent of the body weight. This figure can be used in calculating the amount of water needed to overcome the dehydration factor in such a patient, example, for a 60 Kg patient, 6 per cent equals 3600 cc.

Dehydration in patients, however, is usually not a simple problem of water deprivation but is generally a combination of an inadequate water intake and a loss of electrolyte-containing fluid, as by vomiting. Because of the loss of electrolytes water alone will not correct the dehydration, but physiologic saline or Ringer's solution will since each of them has water and the chief electrolytes needed. The problem is how to give a sufficient amount of saline solution and yet avoid the dangers of an excess. In the sick surgical patient, which very commonly means a patient with sepsis or malnutrition or severe liver damage, or a combination of any of these, an excess of sodium chloride easily produces edema of the depen-

dent parts or even of the lungs and other viscera. The first thought of the surgeon on finding edema in a patient who has been receiving fluids parenterally should be, "What is the plasma protein level, and how much salt solution has been given?"

From a study devised to learn just how much salt solution to give to dehydrated surgical patients depleted of electrolytes, the following rule was developed. For each 100 mg that the plasma chloride level needs to be raised to reach the normal (360 mg per cent), the patient should be given 0.5 Gm of sodium chloride per kilogram of body weight.

This *clinical rule*, which was formerly advocated for the correction of dehydration and restoration of the depleted electrolytes

during the preoperative and postoperative periods has been shown to be dangerous and ineffective. It is dangerous since there are many individuals who are incapable of tolerating small quantities of salt in the immediate postoperative and postanesthetic periods. It is ineffective because the plasma chloride does not maintain a fixed relationship to the sodium ion and does not necessarily vary directly with the extracellular fluid volume. The restoration of the extracellular fluid deficiencies should not be made primarily upon the variation from the normal ions or molecules of the blood (carbon dioxide combining power, hemoglobin, plasma proteins, Cl, etc.) but upon the clinical status and physiologic response of the individual to the administration of parenteral fluids.

Programs for the maintenance of a normal water and electrolyte balance should be kept as simple as possible. The surgical staff should think of water requirements in terms of so much for vaporization and so much for urinary output. The administration of physiological saline or Ringer's solution for restoration of lost electrolytes to normal and their subsequent maintenance at normal levels can be carried out by volume for volume replacement. The subject of water and electrolyte balance forms an important chapter in preoperative and postoperative care and its skilful handling according to the needs of the patient will yield gratifying results.

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#### POSTOPERATIVE CARE

**General Postoperative Care.**—While the general postoperative care is mainly carried out by the nurses, the surgeon is solely responsible for a smooth convalescence. The

comfort of the patient will depend on the intelligent and careful orders of the surgeon. The technical perfection with which an operation is performed is no positive index of the postoperative course. It is just as important to give the same meticulous attention to postoperative detail as to operative technique and there is no excuse for careless postoperative management. It has no place in surgery. The maintenance of fluid and electrolyte balance, thoughtful ordering of diet and sedatives and attention to the many other postoperative details must never be lost sight of by the careful conscientious surgeon. Attention to the details will often spare the patient many disagreeable complications and convert what might have been a stormy convalescence into an uneventful one.

**Diet.**—Most patients recover from an anesthetic either local or general naturally desire water. Vomiting invariably follows most surgical procedures. Therefore water is usually not permitted until from two to four hours has elapsed after the last signs of nausea have disappeared. Invariably water is given in teaspoonful doses, moderately warm although occasionally the surgeons will order it ice cold. If the patient tolerates these small amounts well, greater quantities may be given but under no circumstances should a patient be permitted to drink freely and without restraint. If there are definite contraindications to the early oral administration of fluids, sucking cracked ice often relieves the agony of a dry mouth and an unquenchable thirst. It is not advisable to allow a fluid diet until the day following operation. The fluids commonly used are broths, gruel, plain tea and egg albumen water. Four ounces may be given at a time. An occasional patient may express a desire for ginger ale and very often this will be tolerated when all other liquids have failed. Orange juice and other fruit juices so frequently requested are not well borne by the majority of patients. Milk may be added on the second postoperative day. It is an almost perfect food for it is quickly digested and is almost entirely absorbed. Since it has a high caloric value it provides considerable nourishment. Unfortunately, however, some patients will not tolerate whole plain milk. Barley water, lime water,

plain water seltzer Vichy or a little brandy added to milk will often overcome this intolerance. While as a general rule it is not a good policy to employ alcoholic beverages such as brandy or whisky the writer believes that they have definite indications. Certainly a patient who has been accustomed to alcohol for years should be given it early in the postoperative course in sufficient amounts because sudden withdrawal might bring on delirium tremens. A person who is addicted to alcohol may require from 1 to 2 oz of whisky three times a day. On the other hand some surgeons consider alcohol to be a definite and distinct stimulant prescribing it for weak and debilitated patients within the first days after operation.

Full fluids should be administered at frequent intervals and whenever possible they should be served warm. They should be immediately stopped if nausea or vomiting occurs. If the vomiting becomes pernicious or actual gastric dilatation is suspected a Levin gastric tube should be inserted and suction drainage applied without hesitation. Fluids may then be permitted freely if there is no postoperative contraindication. Naturally under these conditions whatever is ingested will be immediately siphoned but the psychic thirst of the patient will be relieved. The Levin tube may be removed as soon as the gastric fluid intake measures more than the output. It should be a routine nursing procedure in all institutions to chart the fluid intake and output as it is a rough method of estimating fluid balances. It is extremely important to know the quantity of fluid administered orally and parenterally, the amount of drainage through a Levin tube or an intestinal fistula and the amount of urine excreted. The urinary output will often give some clue to the activity of the renal function and will indicate beginning suppression and impending uremia, the early recognition of which is important.

A selected soft diet is usually allowed on the third day as a routine measure. This is permitted if the bowels have moved either naturally or aided by a cathartic or enema.

It must never be forgotten that the diet is a most important postoperative consideration. No two patients can be nourished alike for their individual caloric needs may be entirely different and it is a grave error

to feed patients in a routine manner. The factors which alter diet are many. The age, the general physical condition at the time of surgical intervention, the character of the operation and the postoperative course are important factors in determining not only the amount and kind of food but the frequency and manner of feedings. Many patients suffering from chronic diseases such as nephritis, diabetes, rheumatism and allied conditions will merit special consideration. A patient who has had an operation for hernia does not require the same type of food as one who has had a gastric or intestinal resection and the type of food given to a patient with enterostomy for ulcerative colitis will differ naturally from that given to a patient with a colostomy for carcinoma. A woman of sixty without teeth cannot be expected to digest the ordinary hospital fare with the same facility as a boy of twelve and a frail woman of 100 pounds cannot be expected to consume as much food as a laborer weighing 180 pounds.

Diets must be served under the supervision of an intelligent dietitian and the patient must be educated as to which foods are best for his condition. He should be warned against obliging relatives and kind friends who often bring home-cooked food and delicacies which may prove detrimental to his health. It is not unusual to have gastric disturbances occur after visiting days because of the candy and fruit which were surreptitiously smuggled in by visitors. This evil should be tactfully and carefully controlled. It has been stated with certain reservations that a soft diet provided the postoperative course has been smooth is allowed on the third day, and gradually other more solid articles are added until the so-called regular diet is tolerated. This is the usual routine following the simpler abdominal procedures such as appendectomy, cholecystectomy and the majority of gynecologic operations. Naturally if the peritoneal cavity has not been opened the patient may be given a soft diet on the second day. This is especially true following operations on the head and neck, orthopedic procedures and the majority of hernioplasties. There is no objection to it especially if the patient is hungry and expresses a desire for food.

There are exceptions to the usual routine of dieting especially in the field of intestinal surgery. Procedures involving the stomach duodenum and small intestine require unusual care. Fluids as a rule in these cases are not given until twenty-four hours after operation. The water and electrolytic balance in the meantime is maintained parenterally by Murphy drip or hypodermocentesis. Water is allowed in teaspoonful doses hourly starting the second day. If no untoward symptoms develop the amount is gradually increased as tolerated by the patient. Milk is then carefully added in measured amounts alternating with water and if this is well tolerated the patient may be safely started on the standardized Sippy diet. On the other hand a patient who has been subjected to colonic resection may have oral fluids much earlier usually on the first day but in these cases a low residue diet should never be given until sufficient time has elapsed to establish the competency of the intestinal suture line. Naturally in this type of case the administration of fluids by rectum is strictly forbidden.

**Hypoproteinemia**—The importance of protein in surgical convalescence has recently been appreciated. Deficiency of body protein, i. e. hypoproteinemia recognized by a lowered content of serum albumin and globulin of the blood may give rise to many postoperative symptoms. It may contribute indirectly to surgical shock, act as a factor in the suppression of urine and cause edema about a recent gastrointestinal anastomosis sufficient to produce obstruction. In some cases hypoproteinemia may give rise to peripheral edema and in others it may materially impair wound healing.

Treatment of hypoproteinemia consists in the replacement of proteins orally. Diets rich in amino acids such as milk, cottage cheese, lean meats, liver, eggs and soy beans should be prescribed. If this is impossible the intravenous administration of whole blood, blood plasma and amino acids in the form of 5 per cent amigen and 5 per cent glucose will often effectively elevate the lowered protein content of the blood.

**Sedatives**—Relief of pain after operation is of prime importance to the patients and the first duty of the surgeon is to prevent undue suffering. During the past decade

innumerable proprietary remedies have flooded the surgical literature but whatever may be said pro and con on their behalf morphine and codeine still remain the two absolutely dependable and reliable drugs. Their administration must be carefully controlled. They should not be given promiscuously since liberal and careless administration of these narcotics, especially morphine, has been responsible for drug addiction. It is customary to administer morphine hypodermically in  $\frac{1}{4}$  grain doses with  $\frac{1}{150}$  grain of atropine but here again judgment must be employed. The dose should be sufficient to control pain yet not large enough to cause toxic manifestations. Nurses universally have been duly instructed and warned of the depressing tendency of this drug and if the respirations become unduly slowed and other toxic symptoms are manifest no time should be lost in administering the appropriate antidote. In those cases in which morphine produces nausea or stimulation or in which there is sensitivity to it, atropine or dilaudid may be used hypodermically. It is a good plan to substitute codeine for morphine as soon as possible and as conditions improve to make another change employing one of the invaluable barbiturate derivatives. For restlessness without marked pain, triple bromides, phenobarbital (luminal), nembutal or secobarbital should be employed. A highly neurotic patient who persistently begs for hypodermic medication will often be relieved of the most terrific pain by a sterile hypodermic injection of saline solution.

Occasionally toxic psychosis develops after operation and the patient becomes irrational and difficult to control. Hyoscine hydrobromide by hypodermic injection or paraldehyde, chloral or avertin by rectum in sufficient doses will usually control the manifold manifestations of these unfortunate persons and will tide them over until consciousness or orientation has been established.

**Pneumonia**—Pneumonia still remains one of the most serious postoperative complications. It still augments surgical mortality and morbidity in spite of the use of sulfonamide drugs and oxygen therapy. A full discussion of postoperative pneumonia has been given elsewhere but it is so important that it may

not be amiss to repeat and emphasize a few points. Pulmonary complications are more frequent in the aged because they are especially prone to hypostatic congestion. Pneumonia is more apt to follow operations involving the upper abdomen because of subsequent reflex diaphragmatic paralysis leading to basal pulmonary atelectasis. There is much which can be done to combat these factors prophylactically. Frequent careful changes of the position of the patient in bed will do much to diminish the incidence of pulmonary hypostasis. Careful administration of carbon dioxide gas will stimulate and increase the depth of respirations by hyperventilation of the lungs. At no time should the respiration be hampered. Great care should always be taken that free respiratory movement is not hampered by cumbersome and confining dressings. Adhesive plaster if used for upper abdominal wounds should never be applied across the abdomen in such a way as to restrict the respiratory movement of the lower ribs completely. These simple instructions if religiously followed will do much to diminish the frequency of postoperative pneumonia.

**Pulmonary Atelectasis.**—In those cases in which a diagnosis of pulmonary atelectasis has been made if a cough, a change of position or a slap on the back does not discharge the mucous plug bronchoscopy expertly performed may be extremely efficacious in removing the bronchial secretion by suction.

**Out of Bed.**—The patient may be permitted to leave his bed when the surgeon feels that the patient's general and local condition will permit the additional strain. A patient with a clean non-drained abdominal wound is permitted to sit up in bed in from five to twelve days and allowed up in a wheel chair in from ten to fourteen days. There are those of the radical school who encourage the patient to get up as soon as the sutures are removed while those of the conservative school will not allow a patient up until after from sixteen to twenty-one days. A prolonged stay in bed is advised in those conditions in which healing is apt to be delayed especially in cases of carcinoma and recurrent inguinal hernia and the ordinary cases of postoperative ventral and primary umbilical hernia. In the final analysis there

can be no set rule each case must be judged on its individual merits. After the patient has been about in a wheel chair and has developed sufficient strength walking may be permitted. This should always be done under guidance and the patient should never be permitted to indulge to the point of fatigue. [There is now considerable evidence that early ambulation not only is very beneficial to the patient as a whole but is harmless to the wound itself. Particularly in cases in which a transverse abdominal incision has been used the patient is allowed out of bed for a short time on the second or third postoperative day and walking is increased each day thereafter.—Ed.]

**Treatment of a Postoperative Wound**—**Clean Wound.**—Tissues if handled gently at operation under ideal sterile conditions with careful hemostasis and accurate approximation should heal by primary union. The simplest treatment of a non-drained abdominal wound is best. If the postoperative course is normal an abdominal wound may be dressed on the seventh day if the temperature is elevated or the general condition of the patient is not satisfactory the wound must always be inspected without hesitation. Skin sutures of various kinds are removed on the seventh day and deep retention sutures if employed removed on the tenth to the fourteenth day. Michel or other similar types of metal clips because of the fact that they are apt to cut into the skin and leave disfiguring pockmarks should be removed on the fifth or sixth day after an abdominal operation and on the second day after an operation on the thyroid. If after removal of the sutures a skin wound appears to be poorly healed even if the edges are firmly approximated no harm can accrue from further supporting the wound with sterile adhesive straps.

**Hematoma.**—Hematoma is not an infrequent complication of a postoperative abdominal wound. As a rule it is a reflection on the operative hemostasis. While a hematoma in itself is not serious if infection occurs serious complications may develop. The treatment depends mainly on its size. If it is small absorption may take place under conservative treatment if large it may liquefy and subsequently be evacuated either by aspiration without any further measures or the



wound may be incised in its most fluctuating areas and the blood clot evacuated. Occasionally an operative ligature may slip and from the spread of the ecchymosis it may be evident that active bleeding is taking place. In these cases the patient should be immediately taken to the operating room where under ideal surroundings the wound may be reopened, the blood clot evacuated and the bleeding vessel caught and ligated.

**Infected Wound**—If inspection of the wound reveals an inflammatory reaction the proper treatment should be immediately instituted. If cellulitis is present all effort should be made to localize the infection. Dry or moist heat, poultices and other counter irritants have all been found most efficacious. Once the infection has localized the wound should be opened and adequately drained for when frank suppuration is present ventilation is required and the radical drainage of a wound is the most conservative measure in the treatment of infections of this order. An infected wound regardless of its location drains better with wet than with dry dressings. It appears to be of little moment what solution is used to moisten the dressings but they must be kept wet not simply damp. Dressings may be kept moistened either by frequently changing them or by covering the wet gauze with rubber tissue which prevents evaporation or by inserting a rubber catheter in the dressings and introducing fluid through it at stated intervals.

**Gas Bacillus Infections**—(See section on Gas Gangrene.)

**Drained Abdominal Wound**—Treatment of drained abdominal wounds varies according to the routine of the individual surgeon. A few general rules however may be enumerated. Drainage tubes, drains and packing should not be removed either too early or completely at a single dressing. Drains should be progressively shortened as the discharge diminishes. Then the facts should be recorded on the patient's chart. If a fecal fistula develops the drainage material should be removed immediately because its presence might serve only to compromise further the damaged intestinal wall.

If the discharge from a deep abdominal wound is fecal or is extremely purulent and copious it is advisable to irrigate the wound

gently through one of the drainage tubes with some warm solution. This may be repeated as often as necessary. Irrigation should always be carried out gently, the pressure of the fluid should always be low and only a small amount should ever be introduced.

**Fistula**—It is most important to protect the skin about any draining wound carefully, especially if it shows the slightest tendency to become irritated by the discharge. This is especially true in those cases in which a gastric, duodenal or intestinal fistula has developed. The skin may often become irritated following cholecystectomy, especially if there is a biliary fistula and particularly if the bile contains activated pancreatic ferments. The most important prophylactic measure in these cases is to keep the drainage from coming in contact with the skin. This may be accomplished by continuous electrical or water pump suction which will keep the wound practically dry. If this apparatus is not available the wound should be left exposed and watched constantly by a nurse. As soon as any drainage appears in the wound area it should be gently sponged away with cotton wipes.

Another distinct advantage of suction is that gastric, biliary and duodenal secretions that are of value to the patient may be collected and saved. If necessary the drainage may be re-fed to the patient through a Levin gastric tube or through a jejunostomy tube.

The skin itself may be protected against the irritating digestive ravages of some of these secretions by a variety of substances. Lanolin, paraffin, Beck's paste and bronze powder are invaluable. Wet dressings soaked in beef juice, especially in cases of gastric and duodenal fistulas, have proved to be efficacious in controlling the digestive action of the various ferments.

**Disruption of an Abdominal Wound**—Disruption of an abdominal wound or dehiscence with or without exposure of the abdominal contents (evisceration) is a rather rare complication occurring in from 1 to 2 per cent of all abdominal cases. It is important to be familiar with the condition and recognize its implications because it is an extremely difficult postoperative complication and is attended by a high mortality. It is most apt to occur in illnesses of a pro-

tracted nature attended by emaciation and anorexia and weakness and in those cases of acute and chronic intoxication associated with long periods of fever. These conditions devitalize the patient sufficiently to interfere with the reparative powers of the tissues and with healing of the wound. Therefore it is a likely complication in carcinoma and is not infrequently seen in certain gynecologic conditions especially those of a malignant nature and in uterine fibroids. The diagnosis is simple and rarely offers difficulties. A dressing previously dry and clean which suddenly becomes stained a salmon color or saturated with a bloody serous discharge should make one exceedingly suspicious of dehiscence even if inspection shows that the skin is apparently healed. If palpation however gives the impression that the underlying tissues have separated the removal of one or two skin sutures will readily confirm or allay the suspicion.

Occasionally in a case of dehiscence the patient may present the early symptoms of acute intestinal obstruction due to subcutaneous kinking of a prolapsed knuckle of intestine. Quite often an intelligent patient can make his own diagnosis by being conscious of a sudden 'giving away' of the operative wound following some excessive strain. The diagnosis calls for immediate active surgical intervention. There are several methods of treatment available. The most important however is either the tampon method or secondary suture of the abdominal wall with drainage. The tampon method is the simplest easiest and least shocking. It should be the method of choice when infection is present or in the case of a desperately ill patient in whom disruption occurs secondary to general peritonitis.

The treatment consists in thoroughly washing the prolapsed omentum and intestines with copious saline irrigations and then gently replacing the exposed viscera within the abdomen keeping them in place with iodoform gauze packings. The edges of the wound are then approximated with sterile adhesive straps. This procedure can be carried out with the patient in bed and without an anesthetic. The packing is gradually removed as healing progresses. Secondary su-

ture with interrupted heavy through and through silk sutures is more complicated and it necessitates the use of an operating room and anesthesia. Such a wound is always drained and as a rule six weeks must intervene before the patient can be discharged.

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## POSTOPERATIVE COMPLICATIONS

**Abdominal Distention.**—Postoperative abdominal distention is a condition arising primarily on the basis of muscular atony of the gastrointestinal tract in which gas collects within the lumen of the gut, this in turn causes a localized or generalized increase in the girth of the abdomen displacement of organs stretching of tissues including any abdominal incisions that have been made and sensations of tenseness and discomfort if the digestive tract is quiescent. Cramping colicky pains if intestinal movements are active. Distention occurs so regularly after laparotomy, especially after operations on the upper abdominal organs that it may be regarded as the usual consequence of these operations. It varies in degree from slight flatulence to the extreme degree seen in toxic ileus. The physical findings consist of generalized or localized increase in the size of the abdomen together with increased tympany on percussion plus abnormal findings on auscultation disorderly peristalsis with borborygmi in case intestinal movements are active and a silent abdomen in cases of paralyzed musculature.

Merely surgical exposure of the contents of the abdomen to air usually produces prompt cessation of all intestinal movements. Under splanchnic or spinal analgesia however considerable activity may persist for variable periods. The customary interpretation of these facts is that the muscular atony induced by laparotomy is essentially a reflex phenomenon mediated by the splanchnic or inhibitor innervation. The primary atony can presumably be exaggerated and prolonged by such general conditions as psychic apprehension and dehydration which affect the sympathetic nervous system and more especially by local peritoneal reflexes instigated by damage to the peritoneum such as result from ordinary handling retraction

mechanical pressure by gauze packs or drainage material or the irritation of inflammatory exudates whether resulting from bacterial action or not. It seems likely that disturbances of secretory and absorptive function go hand in hand with disturbances of motor activity and resumption of function occurs first in a disorderly fashion.

For a variable period of time postoperatively usually for from twelve to twenty-four hours the intestinal tract is in a quiescent state, during this period distention may be slight or considerable but the patient usually suffers little. With the resumption of motor function however the character of the distress changes and definite cramping colicky pains are experienced the so-called gas pains.

As the normally functioning intestine finds greater difficulty in propelling and expelling gas than semisolid and solid contents it is not surprising that a bowel which is functioning in a subnormal and disorderly fashion is largely powerless to deal with gas. Furthermore whereas the gaseous contents of the normal bowel consist largely of carbon dioxide which is formed by processes of putrefaction or the action of digestive ferments and which is easily absorbed by the blood stream and excreted through the lungs the gas of postoperative distention is largely atmosphere air four fifths of which consists of nitrogen a gas which is absorbed only very slowly (McIver *et al*).

**Treatment.**—On the basis of the preceding discussion of the etiology it will be appreciated that the treatment of postoperative distention is preeminently prophylactic. All those factors which tend to disturb the motor and secretory functions of the bowel should be reduced to a minimum—preoperative purgation and catharsis starvation with respect to both food and water operative exposure to the air drying chilling and manipulation of the intestine, air swallowing should be prevented as far as possible by skill in inducing and maintaining general anesthesia and combating postoperative retching gagging and vomiting. From the point of view of this particular complication sphincteric and spinal anesthetics offer a distinct advantage over general anesthesia in that they both tend to stimulate rather than to depress peristalsis.

On the theory that the normal mechanism for disposing of the gas of abdominal distention is absorption not expulsion some authorities advocate only conservative therapy. This includes provision for escape of any gas spontaneously finding its way to either end of the digestive tract relief of external pressure on the abdomen and spasm of the abdominal wall and liberality in the exhibition of narcotics (morphine) for the relief of acute discomfort.

A Levin catheter passed through a nostril into the stomach and left there provides a means for decompression of the proximal end of the digestive tract. Once gas has been evacuated from the stomach how *ever* it is likely that some gas in the duodenum now finding a favorable pressure differential will regurgitate into the stomach and escape through the tube. Ultimately the reason to hope that some degree of decompression of the entire small intestine may occur in this way. From this point of view it would seem desirable to pass the catheter directly through the stomach into the duodenum if possible. Application of Wangensteen's suction to the free end of the catheter obviously creates a still more favorable condition for the evacuation of gas by providing gentle negative pressure. In cases in which Wangensteen's suction is not effective introduction of a Miller Abbott tube may be tried remembering however that the two conditions for its successful use are not as likely to be present as in dynamic ileus *viz.* that it can be made to pass the pylorus in the first instance and in the second instance that once it has found its way into the duodenum peristalsis will be sufficiently active to carry it down the intestine. Free means of escape for any gas finding its way into the rectum is provided by insertion of a soft rubber rectal tube. Such a tube may be introduced for an hour at a time at intervals of an hour or more.

The unavoidable distention caused by gas which can find its way in neither direction can be relieved by loosening whenever possible tight mechanical bandages and other appliances elevation of the bedclothing on a suitable wire cage or cradle to relieve local pressure on the abdomen and the application of heat to relieve muscle spasm (though recent experimental evidence suggests that

intestinal activity may be inhibited by application of heat to the abdominal wall—Bisgard and Nye) dry heat in the form of irradiation from incandescent electric globes has the advantage over moist heat that it can be made to affect the whole expanse of the abdomen even that portion covered by bandages and so that it can be kept optimally constant without periodically disturbing the patient or moistening the bed clothes.

Those who think that peristalsis must be largely relied upon for the evacuation of gas advocate the use of stimulating drugs and perhaps also enemata and flushes. The time-honored enema and flush whether plain or medicated with soapuds, turpentine or oil, peppermint or other substances is at present widely regarded as of questionable value largely because it may increase rather than relieve discomfort, particularly if carelessly administered. The status of drug therapy in the treatment of intestinal atony in general and distention in particular is highly controversial. Opates, physostigmine, prostigmine and the derivatives of choline have been found experimentally to stimulate motility of the small intestine and pitressin (one of the active principles of pituitrin) to stimulate motility of the large intestine. Some authorities however find that the small intestine and colon obey a law of reciprocal activity such that when one is active the other is inactive. Thus all of these drugs may have opposing actions which tend to cancel each other out. The synthetic substance prostigmine seems to be the best single drug for stimulating peristalsis according to clinical experience but a combination of drugs may be more rational (ergotamine tartrate 0.25 mg., prostigmine methyl sulfate 0.25 mg., and pituitrin 125 units as advocated by Adler, Atkinson and Ivy). Intravenous injection of hypertonic sodium chloride solution causes strong peristaltic activity in experimental animals and has been advocated for clinical use (20 cc. of a 10 per cent solution introduced very slowly—four to five minutes is recommended by Orr).

No patient with abdominal distention should be treated without constantly bearing in mind the fact that the distention may be transient and almost physiologic or it

may be an indication of incipient peritonitis, mesenteric thrombosis or intestinal obstruction.

**Dilatation of the Stomach**—Distention of the stomach differs from simple distention in several important particulars. The contents of the distended stomach are mainly gaseous whereas the contents of the dilated stomach are mainly fluid, the fluid contents of the latter are very obviously products of secretion because reaccumulation of the fluid occurs rapidly and repeatedly after complete evacuation of the stomach by intubation even though nothing is taken by mouth in the interim. Distention of the stomach produces discomfort which borders on pain whereas dilatation may produce little discomfort and few symptoms except regurgitation. Distention of the stomach tends to undergo spontaneous recovery, dilatation tends to progress rapidly to a fatal termination.

Dilatation of the stomach may occur both early in the postoperative period and abruptly, death on the operating table has been reported as due to this condition.

Acute dilatation of the stomach is probably due to reflex gastric inhibition either visceral or sensory nerves forming the afferent limbs of the reflex arc and the splanchnic and vagus nerves forming the efferent limb. Distention of the organ is then superimposed in the first instance by swallowed air and later by accumulation of normally secreted gastric juice and regurgitated duodenal secretion, pancreatic juice and bile. Inasmuch as these secretions cannot be appreciably absorbed from the stomach or duodenum they accumulate passively and the natural progress of the condition is fatal especially because of failure to absorb chlo-

effortless regurgitations then recur at short intervals and soon the originally watery material becomes streaked with green or black. If the patient is conscious he characteristically complains of some gastric distress at this stage and inspection of the epigastrium may reveal definite localized fullness. Later if nothing is done to relieve the condition regurgitation of large quantities of brownish or greenish fluid occurs. As more and more fluid is evacuated dehydration and hypochloremia develop, the eyes become sunken, the tongue becomes coated and dry and the face looks drawn and anxious.

**Treatment**—Dilatation of the stomach does not occur in rationally and skilfully treated patients except in rare instances. Immediately after all laparotomies involving manipulations above the level of the umbilicus prudence dictates gentle gastric lavage and in most cases the nasal catheter used for this purpose should be left in situ in order that aspiration may be subsequently performed at suitable intervals. Aspiration of gastric contents should be performed without hesitation for all other patients who for any reason do not appear to be doing well or who vomit more than once. The cause of the condition would not always be relieved thus it is true but acute dilatation of an empty stomach obviously cannot occur and in most cases of acute dilatation the condition begins as it probably does without organic obstruction and becoming progressively more and more complete only as the viscus becomes increasingly distended would be completely obliterated.

Established gastric dilatation amounts to a special instance of high intestinal obstruction and the treatment is that of high intestinal obstruction—functional in type unless there is some particular reason for assuming the presence of an organic stricture. Accordingly the indications are for decompression of the stomach in order to avoid mechanical distortion of the gastrointestinal tract and equilibration of all factors concerned with establishing and maintaining motility of the gastrointestinal musculature especially the water balance and ionic balance.

In many cases the device described by Wangensteen in the section on intestinal obstruction is preferable to simple periodic suction not only because it removes gastric

secretion and gas as fast as they accumulate thus keeping the stomach (and most likely the duodenum and at least part of the jejunum as well) quite empty but also because with such an apparatus functioning properly the patient may be allowed to drink freely, the fluid drunk being of course promptly aspirated from the stomach by the apparatus. Drinking copiously even though the fluid does not remain in the stomach provides a means of keeping the mouth and throat moist and to some degree combats thirst which may be greatly annoying. When Wangensteen suction is used accurate charting of fluid given by mouth and fluid and gas evacuated from the stomach must be performed both for the purpose of ascertaining whether the apparatus is working properly and also to detect the first signs that fluid is starting on its way down the intestinal tract which may be regarded as a signal of recovery. When Wangensteen suction is continued for considerable periods of time (it may be employed for days if necessary) two dangers must be recognized: (1) production of alkalosis resulting from prolonged removal of chlorides from the stomach and (2) pressure damage to the esophagus or larynx. Alkalosis may be prevented by parenteral administration of salt solution. The use of Miller Abbott double-barrelled tubes which provide a means of withdrawing gastrointestinal contents at one level while at the same time adding artificially prepared solutions at another level would theoretically be ideal (decompression of the stomach; addition of water, essential ions and even food to the small intestine) but the practical difficulties are similar to those mentioned under the treatment of abdominal distention.

**Disturbances of Urination—Suppression, Anuria, Oliguria and Retention**—By far the most frequent cause of anxiety with respect to the urinary tract in postoperative cases is failure of the patient to void. Postoperative failure to void may be due to (1) acute failure of the urinary function in the kidney itself, suppression or secretory anuria; (2) blockage of the ureter, anuria or postrenal anuria; and (3) failure of the bladder to empty itself of contained urine, retention. All the conditions are more likely to be partial than complete and accordingly

to cause oliguria rather than complete failure to void

Excretory or secretory failure of the kidney itself suppression of urine according to some observers is sometimes due to reflex or idiopathic causes but probably in the majority of cases is due to more definite factors such as low blood pressure dehydration and blood concentration Fundamentally therefore the treatment is prophylactic and consists in adequate preoperative study of the patient to detect abnormalities of structure and function plus preservation as closely as possible of a normal condition of hydration Curatively the slow intravenous injection of considerable quantities of isotonic or in the more severe cases hypertonic solutions of dextrose may rather promptly reestablish the urinary function Ureteral catheterization is occasionally said to accomplish the same result

Postrenal anuria may be due to any one of a number of conditions capable of producing occlusion of the ureter periureteral edema extraurethral tumors inadvertent sectioning or ligation of the ureter and impaction of a preexisting renal calculus calculous anuria The greatest number of cases follow operations on the uterus and broad ligaments in which case the condition is most often due to edema and is accordingly transitory Complete and permanent blockage of a ureter as by ligation or occlusion by a calculus is rare and necessarily results fatally only in those cases in which the only adequately functioning kidney is on the side of the occlusion

In view of the widespread use of sulfonamides in connection with operations it is important to realize that these substances may form crystals and calculous concretions of crystals in the urine which are capable of producing anuria Because these substances especially sulfadiazine sulfathiazole and sulfapyridine may be several hundred times as soluble in alkaline urine as in acid urine alkalinization with sodium carbonate or sodium citrate by mouth or some equivalent substance by vein (lactates) constitutes an important prophylactic measure against this kind of anuria

Postoperative retention of urine may be due to failure of the urinary bladder to contract with sufficient force to empty itself

True retention of urine can be said to occur only when the bladder has become abnormally full of urine and the practice of referring to every case of postoperative failure to void as a case of retention is pernicious in that it entirely avoids this issue obviously a bladder may fail to empty itself simply because it contains very little urine or none at all Furthermore and just as important patients with retention may actually dribble urine at frequent intervals and still maintain an overdistended bladder this condition is known as distention with overflow Retention frequently follows operations on the urethra itself or adjacent structures and in such cases is due to such factors as impaction of blood clots periurethral edema or too tight vaginal or rectal packing certain operations such as prostatectomy in the male and repair of a cystocele in the female invariably require the use of an indwelling catheter for some days postoperatively to obviate the effects of these mechanical factors When the cause of retention is not discoverable it is most frequently ascribed to atony of the bladder

Within limitations there is much difference of opinion as to the necessity of and indications for postoperative catheterization Most observers agree that the normal urinary bladder is not easily infected as a result of instrumentation Evidence in support of this theory is seen in the relative infrequency with which cystitis develops after properly performed cystoscopy When cystitis develops after catheterization there fore even after repeated catheterization the presumption is either that the bladder was already the seat of an unrecognized abnormality or was damaged as by long-continued overdistention or that the technic was faulty with respect to asepsis On the one hand are those who contend that the mere passage of some definite interval of time such as ten or twelve hours without voiding constitutes sufficient indication for this procedure on the other hand there are those who rarely or never catheterize a patient preferring to allow the accumulation of urine to force the sphincter regardless of the time interval the volume of the urine and even the discomfort of the patient Between these two extremes are others who catheterize or do not catheterize according to specific indications

Probably the safest procedure is to catheterize if distention is causing discomfort if the patient passes small quantities of urine at frequent intervals (which would suggest the presence of retention with overflow) or if inspection or palpation of the suprapubic region reveals a distended viscus the objection to allowing the bladder to become distended by the accumulation of more than 300 or 400 cc of urine is that the organ may suffer mechanical damage especially in the case of the middle aged or elderly patient whose tissues have lost some of their natural elasticity. Catheterization is employed ordinarily only after all reasonable attempts have been made to stimulate spontaneous voiding such as by changing the position of the patient in bed or if at all feasible even allowing a suitably supported standing or squatting position. It should be remembered that some patients find it impossible to void while an attendant is in the room.

In all cases in which catheterization is required and in all cases in which there is a suspicion that the urinary tract has been the seat of a recent infection there should be repeated microscopic examinations of the Gram stained sediment for bacteria. The microscopic diagnosis of urinary infection can precede the development of clinical symptoms and signs by many hours. One of the sulfonamides preferably sulfadiazine in doses of 0.5 Gm three times per day may be given prophylactically in cases requiring an indwelling catheter or in other cases in which there is special reason to anticipate infection.

**Postoperative Pulmonary Complications**—That surgical procedures do actually predispose to the development of pulmonary lesions is shown by the fact that in from 2 to 6 per cent of all patients subjected to major surgical intervention pulmonary lesions develop whereas for some types of operations the incidence is 10 to 13 per cent (47 per cent in males following operations on the stomach and duodenum 36 per cent after operations on the gallbladder—Betts). To account for this predisposition several theories have been proposed all of which have as their basis controlled clinical observations and experimental evidence.

**The Aspiration Theory**—This is the most natural theory as it assumes that aspiration

of such substances as saliva mucus and vomitus together with such pathogenic micro organisms as are invariably present in these substances is mainly responsible. Formerly considerable emphasis was placed on the abolition of the cough reflex during general anesthesia and of the swallowing reflex during tonsillectomy and related operations under local anesthesia as etiological factors and indeed it has been rather conclusively shown that some aspiration of material from the mouth and throat into the trachea and bronchi invariably occurs under these conditions unless a definite Trendelenburg position is adopted and maintained (Lemon). One fact however of universal acceptance seems to cast serious doubt on the supreme importance of aspiration as an etiological factor viz. that pulmonary complications develop with equal or almost uniminished frequency after splanchnic spinal and other analgesics which do not disturb the swallowing and cough reflexes at all and are therefore presumably not associated with aspiration.

**The Embolic Theory**—According to the embolic theory major emboli or showers of minor emboli originating from the upper respiratory tract from thrombotic veins in the environs of operative areas elsewhere in the body from some intravascular thrombus at a distance from the operative site or even from a coalescence of the normally emulsified fat of the blood stream (Lahman *et al*) are carried to the lungs where they set up vascular occlusive or frankly infectious processes depending on circumstances. Major pulmonary embolism and infarcts are of course universally conceded to occur in this manner.

**The Atelectatic Theory**—According to this theory, pulmonary complications are due to collapse of a greater or lesser volume of pulmonary tissue. A plug of viscid mucoid secretion is inspired into the bronchial tree at some point and blocks both ingress and egress of air absorption of residual air then occurs from that portion of the lung distal to the point of impaction and because this tissue becomes functionless and its circulation is profoundly disturbed it readily becomes infected.

Postoperative pulmonary complications occur at least twice as frequently in men as

in women. They are rare following operations on the head, neck and extremities (approximately 0.5 per cent) more common after lower abdominal operations and herniorrhaphies (about 1 per cent) but surprisingly common after operations on the upper abdominal organs, stomach, biliary tract, pancreas and spleen (10 to 13 per cent or more). Pre-existing or incubational respiratory infections act as a definitely predisposing factor. smears and cultures from infectious postoperative lesions of the lungs and bronchi invariably reveal those organisms which characteristically have their habitat in the mouth and pharynx and about the teeth (Smith).

Academically postoperative pulmonary complications can be classified as (1) mechanical (atelectasis and massive collapse), (2) vascular (infarction and embolism) and (3) infectious (abscess and pneumonia). Clinically the most serviceable classification is simply early and late. The early complications alone are discussed in this section and as a matter of fact only the obscure part of this group. Frank pneumonia, massive collapse of the lung, infarction, embolism and gangrene have been given their appropriate consideration elsewhere.

The obscure group of early pulmonary complications usually show their characteristic symptoms and signs within the first two or three days postoperatively, run their course within about five days, though physical signs may persist for as long as two weeks, subside spontaneously and rarely show complications or sequelae. The symptoms consist of elevation of the temperature to 101° to 105° F. without chill, rapid shallow breathing, the upper portion of the thorax alone showing much excursion, a rapid weak pulse, cough (at first unproductive and not associated with physical signs, later productive of purulent but not blood-tinged phlegm in considerable amounts) and scattered coarse rales. Formerly patients with such symptoms were given the diagnosis aspiration pneumonia, ether pneumonia or surgical pneumonitis. Lately terms are commonly used which imply a different etiology, mild or evanescent atelectasis (Mastics), partial atelectasis or hypoventilation (Muller). The group of entities embraced by these various names

though obscure probably accounts for by far the greatest percentage of all pulmonary complications. At the base of the lungs certain early postoperative changes of a definite nature can frequently be demonstrated by roentgenographic examination or even by very careful physical examination which are not associated with any definite clinical symptoms which are usually transitory, which resolve spontaneously and which usually go unrecognized. The skiagram reveals diffuse cloudiness and some mottling and the physical signs consist of diminished percussion sounds, altered breath sounds, rales and tubular breathing. These changes are believed to be due to purely physical factors such as a diminished respiratory excursion due to partial fixation of the lower portion of the lower thorax and relative fixation of the diaphragm, pressure phenomena due to recumbency in bed and possibly also areas of minor atelectasis dependent on bronchial occlusion. It is widely believed that this is the initial process from which by the superimposition of infection most of the other and more severe processes develop.

*Pneumonia*—(See section on Pneumonia)

*Embolism*—(See section on Embolism)

*Massive Collapse of the Lung*—(See section on Atelectasis)

The prophylactic treatment of postoperative pulmonary complications is of fundamental importance. It should be remembered that pulmonary complications are especially likely to develop in men, particularly those who have undergone a surgical operation on the upper abdominal organs. Because such complications tend to occur with especial frequency during epidemics of common colds, influenza, tonsillitis and infections of the upper respiratory tract generally, it should be axiomatic to postpone operations of election on patients who have recently contracted or have been exposed to infections of the respiratory tract and to suspend all but emergency operations during epidemics of such infections. For a similar reason preliminary elimination of all known foci of infection in the mouth and pharynx should precede major operations whenever sufficient time can be allowed for interval healing of the tissues. During the period of anesthesia great care should be taken to prevent general chilling of the patient's



body exposure to drafts and aspiration of saliva mucus and vomitus. Operating with the use of spinal or other forms of local or regional anesthesia probably offers no protection or certainly very little.

Those who adhere to the atelectatic theory of development of most of these complications stress the importance of enforcing normal or exaggerated breathing as far as possible thus maintaining expansion of all parts of the lungs. Administration of a suitable mixture of carbon dioxide and oxygen with a gas anesthesia machine for several minutes before the patient leaves the operating table regardless of the form of anesthesia is widely advocated. After return to bed breathing into and out of an ordinary paper bag for five minute periods several times per day is a convenient method for continuing  $\text{CO}_2$  hyperventilation in case the patient can and will cooperate. (For technic see the treatment of hiccough in the next section.) Deep breathing exercises under the supervision of the nursing staff at stated and frequent intervals during the first few postoperative days are commonly advocated. Some authorities however condemn such procedure as actually favoring the aspiration of plugs of secretion. All seem agreed however that frequent changes of the patient's position in bed are valuable. To be of real value the change of position should if possible be a deliberately planned careful turning of the patient from the dorsal recumbent position to the side or back again as the case may be at intervals of two hours or so. Because experiments show that up to 50 per cent depression in vital capacity may be caused by reflex inhibition of respiration due to pain caused by upper abdominal incisions blocking of the fifth to eleventh intercostal nerves has been advocated by Zollinger to favor deeper respiration in these cases.

When postoperative pulmonary complications definitely develop careful nursing care and the administration of oxygen either alone or in combination with carbon dioxide placing the patient in a sitting or semi sitting position symptomatic and supportive measures and attention to the emunctories and water balance constitute the important part of the treatment. In view of the difficulty of differentiating in the case of an acutely ill patient between early lobar or lobular pneu-

monia which are responsive to sulfonamides (and penicillin) and atelectatic lesions which presumably are not responsive careful attention may well be given to the possible usefulness of early specific therapy with these drugs.

In certain cases special forms of treatment are occasionally indicated. Thus in accordance with increasing appreciation of the role of atelectasis in the production of these lesions early introduction of a bronchoscope should be considered as a possible means of discovering and relieving any bronchial obstruction which may be present provided someone thoroughly skilled in the use of the bronchoscope is available.

**Postoperative Parotitis**—Postoperative parotitis is the non specific infection of the parotid gland with microorganisms of the pyogenic group. Although the parotitis may resolve spontaneously and completely it shows a remarkable tendency to progress to frank abscess formation or gangrene. It is an affliction of middle aged or older adults rather than younger persons it afflicts females more frequently than males and develops in somewhat less than 10 per cent of all patients subjected to major surgical procedures. This complication tends to occur in patients debilitated by long illness prior to operation or in those whose postoperative convalescence is delayed and stormy.

Staphylococci seem to be the causative organism in most cases but pneumococci streptococci and even *B. coli* are often recoverable from an infected gland. The mode of establishment of the infection is not certain some cases may be due to metastatic blood borne infection and others to lymphatic extension but it seems reasonable to believe that most cases represent mechanical extension from the mouth by way of Stensen's duct. The trauma of the anesthesiologist's fingers exerting undue pressure at the angle of the jaw may act as a predisposing factor though the complication is seen in patients operated on under spinal and local anesthesia. Failure of the normal mechanical rinsing action of saliva from the gland secondary to dehydration or failure to chew resulting in stagnation of secretion in the duct system and dryness of the mouth is probably an important factor.

The essential symptomatology consists of

painful localized swelling at the angle of the jaw together with the usual indications of systemic intoxication—fever increased pulse rate and leukocytosis. In some cases the symptoms are all slight the temperature being elevated only a degree or two and the tumefaction being strictly localized in fulminant cases however the temperature may be elevated to  $104^{\circ}$  or  $105^{\circ}$  F and the patient may show spreading edema of the neck face and head accompanied by other evidences of profound sepsis.

The important considerations in the prevention of postoperative parotitis are careful attention to oral hygiene prevention of dehydration preservation of the function of chewing—as by having the patient chew gum—and avoidance of trauma to the parotid gland during the induction and maintenance of general anesthesia.

When the condition actually develops an attempt should first be made to demonstrate and insure patency of Stensen's duct if there seems to be a possibility of impaction of a calculus or inflammatory stenosis. Otherwise except in the fulminant cases the treatment may be conservative and supportive for a period not to exceed forty-eight hours an attempt being made during this interval to favor spontaneous resolution without pus formation by the application of heat in the form of hot moist compresses over the involved area. Advantage should be taken of the probable usefulness of sufficiently large doses of sulfonamides or penicillin which should be given early. At the Mayo Clinic (Rankin and Palmer) radium application over the affected gland has proved to be of definite value particularly if the application is made within one or two hours of the recognition of the complication. From two to four 50 mg. tubes of radium are applied at distances of 2.5 cm. from each other filtration being provided by 2 mm. of lead 1 mm. of brass and 0.5 mm. of silver and a dosage of from 800 to 6000 milligram hours is given depending on the estimated extent of the process. Many who have used this form of therapy regard it as virtually specific. There seems to be no reason why roentgen treatment should be less efficient than radium treatment if the latter is not available and the patient can be safely moved to a suitable x-ray machine or if the machine can be

transported to the bedside. An estimated suitable application in the latter case is 40 to 50 per cent of one erythema dose filtered through 4 to 6 mm. of aluminum at a moderate (135) kilovoltage (Decker).

In the early fulminant cases and in the milder cases which become more serious with the passage of hours radical incision and drainage should be practiced without hesitation for the gland has a firm capsule and is deeply placed thus making it practically impossible to determine whether suppuration has or has not actually occurred extensive suppuration or even gangrene may otherwise develop undetected.

The mortality in postoperative parotitis may in any considerable series of cases approach 40 per cent though this mortality is by no means solely due to the complication itself the general condition of the patient usually being poor. If radium is applied early and drainage is instituted on slight indications the mortality may be materially reduced.

**Hiccough**—Postoperative hiccough seems to be due most frequently to a reflex irritated by mechanical or chemical irritation in the stomach or lower portion of the esophagus or the region of the gallbladder or indeed to any lesion capable of producing irritation of the peritoneum in the subdiaphragmatic portion of the abdominal cavity. Accordingly hiccough is relatively common after operations on the gallbladder and stomach especially in males. Lesions of the brain and spinal cord are apparently responsible in some cases.

Because postoperative hiccough may constitute the presenting symptom in such serious intra abdominal complications as incipient peritonitis intestinal obstruction and residual abscess formation a careful examination of the patient should be made to detect such conditions if present. The cause being so variable and so frequently obscure both the prophylaxis and the active treatment of postoperative hiccough are unsatisfactory. Occasionally loosening or removal of drainage material loosening of a too tight binder or mere movement of the patient in bed may suffice to relieve hiccough but in most cases other measures are required. These are (1) gastric lavage with or without Wangenstein suction (2) inhalation of

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